Handbook of Research on
Creative Problem-Solving Skill Development in Higher Education

Chunfang Zhou
Handbook of Research on Creative Problem-Solving Skill Development in Higher Education

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Foreword

Higher education students enter college with a variety of perceptions and goals. Some merely continue on their education pathway because that is the culture of their family. Certain students are expected to enter a specific major as a result of family expectations. Others may have been influenced by a favorite teacher or family member who they want to emulate. Some don’t have a clue as to what to major in. Another group of university students may question what career options they have as a function of selecting a college major. This is also evident at the graduate level. Perhaps a more salient question is what skill sets do I need to develop in order to maximize my career options? This thinking has led to what is now being referred to as “unbundling” of degree requirements as UK’s Coventry University has done. The unbundling concept is analogous to media companies offering individual internet/cable options rather than requiring that the consumer purchase a bundle of programs, some of which are never used. Likewise, the traditional prescribed college curriculum may one day not meet student needs to become employable. A smart approach to answering what skills are needed today and for the future is to investigate projected directions of major employers.

For example, IBM in a 2010 global survey of more than 1,500 CEOs from 60 countries and 33 industries worldwide were asked what is the most important competency that leaders of the future need? Creativity was the winner. Creativity was selected as the most crucial factor for future success. Thus, in light of new government regulations, changes in global economics, industry restructuring, and emerging customer priorities - more than management skills, financial acumen, imagination or even robust personality - successfully navigating an increasingly complex world will require a creative workforce as well as worksites that establish creative environments, which foster innovation. Specifically, leaders of the future are courageous enough to make decisions that modify the status quo, are comfortable with ambiguity, encourage invention and innovation, and demonstrate grit (perseverance). In fact, in 2014, Mark Wilson, at Fast Company, reported that IBM announced more than $100 million in global investments that includes opening Interactive Experience labs around the world and hiring 1,000 new employees with expertise in design thinking and creative problem solving skills.

The design firm IDEO, in their 21-year history, has consulted in creative endeavors with Apple, Samsung, Procter & Gamble, OXO, Walgreens, Ford, Toyota, and 3M who are in constant need of fresh ideas. IDEO’s latest innovation is to include small entrepreneurial companies who IDEO will mentor in a five-month boot camp. More and more, corporations are developing in house talent managers and creating positions with titles like Chief Creative Officer, Chief Innovation Officer, and Director of Creativity. Developing in house creative employees not only is more economical than hiring outside expensive consultants who many times have a great personality but minimal understanding of the client’s needs, but also provides sustainability of creative solutions for precise corporate needs.
Foreword

The online Creativity and Innovation Masters and Ed.D. degree programs offered by Drexel University’s College of Education join the wave of corporate and educational institutions embracing creativity studies. The Drexel creativity and innovation curriculum is comprised of foundational theories and research, worksite applications, historical knowledge, global comparisons, current issues, various research approaches, and a diagnostic assessment case study application of creativity to personal and/or professional problem solving. These are fully online programs that enroll students from across the United States and beyond. The students mainly are in education and corporate positions with a few military and individual entrepreneurs.

Complementary to the coursework is the Reisman Diagnostic Creativity Assessment (RDCA), a free Apple App, still in development, that may be downloaded via iTunes for the iPad, iPhone, and iTouch or click: https://itunes.apple.com/us/app/reisman-diagnostic-creativity/id416033397?mt=8. The RDCA taps 11 creativity characteristics that have emerged from over 70 years of creativity research, especially Joy Guilford and E. Paul Torrance. Following are the 11 RDCA creativity factors and definitions: Originality - a novel response that is statistically unique, Fluency - generation of many ideas (involved in brainstorming), Flexibility - generation of different categories of ideas, Elaboration - adding details to verbal, textual and figural stimuli, Tolerance of Ambiguity - comfortable with uncertainty, Resistance to Premature Closure - keeping an open mind, Convergent Thinking- analyzes and evaluates solutions and comes to closure, Divergent Thinking - generates many solutions (related to fluency), Risk Taking - adventuresome or willing to take a chance, Intrinsic Motivation - involves engaging in behavior because it is personally rewarding, Extrinsic Motivation - needs reward or reinforcement.

The free RDCA app provides a Likert-type assessment resulting in a self-report designed to be used diagnostically to identify one’s creative strengths, rather than to predict creativity. The RDCA results can be used to provide the assessment taker with an instant overall creativity score, as well as scores to identify specific creativity factors in which the taker may already be strong, factors they may be personally satisfied with, and factors the taker may wish to strengthen through creativity exercises. An interpretive table is available from freddie@drexel.edu as described below:

### RDCA Interpretation

Developing problem-solving skills in higher education students, involves many of the RDCA factors. Often students are unaware of their creative strengths. In fact, many times my students comment that becoming aware of their creative strengths has changed their lives. They also realize that their creativity can be enhanced through techniques such as practice in generating many ideas and novel ideas, not coming to premature closure when either attempting to identify the real problem in a situation or in finding the best solution to a problem, learning to accept the unknown; and of course engaging in brainstorm-
A free online strategies manual is expected to be completed in the fall of 2016, which will present creativity enhancing tools and techniques that are categorized by the 11 RDCA factors.

It is noted that developing creative problem solving skills at the University level can be daunting, as students too often have come through a convergent type education from kindergarten on. They were rewarded with staying within the lines while coloring in a workbook, they mainly were administered tests where credit was attained by providing one correct answer, and essay tests required regurgitating lecture and/or textbook information. Even laboratory-based education too often involved repeating experiments to the letter and then filling in blanks in their lab book. This environment inhibits development of creative thinking. In fact, blocks to creativity emerge such as intolerance of the unknown, not taking risks due to fear of failing, lack of grit (perseverance), low self-efficacy (lack of confidence in what one can do), or reluctance to try something new. Thus, by the time they get to college, many students have been engrained with the opposite thinking and skills that are needed for creative problem solving and the creativity characteristics that the RDCA assesses. Also, there may be a disconnect between student

**Table 2. Example I: A Total Score of 240 means you selected the highest scoring option for each item for 100% of the items. (Note: Some items were reversed score, i.e., selection “Strongly Disagree” was the highest scoring option instead of “Strongly Agree.”)**

<table>
<thead>
<tr>
<th>RDCA Score x Factor (Maximum points possible)</th>
<th>Score of, Equivalent %</th>
<th>Classification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Score (240 possible score)</td>
<td>204-240, 85%-100%</td>
<td>Very High</td>
</tr>
<tr>
<td></td>
<td>144-203, 60%-84.5%</td>
<td>Moderately High</td>
</tr>
<tr>
<td></td>
<td>120-143, 50%-59.5%</td>
<td>Average</td>
</tr>
<tr>
<td></td>
<td>96-119, 40%-49.5%</td>
<td>Low</td>
</tr>
<tr>
<td></td>
<td>0-95, 0%-39.5%</td>
<td>Very Low</td>
</tr>
</tbody>
</table>

**Table 3. Example II: A score of 22 for the factor Originality reflects that you obtained 61% of the possible 36 Originality factor points comprised of the 6 Originality RDCA items.**

<table>
<thead>
<tr>
<th>RDCA Score x Factor (Maximum points possible)</th>
<th>Score of, Equivalent %</th>
<th>Classification</th>
<th>Factor Definition</th>
<th>RDCA Items Related to Factors (no.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Originality (36 possible score)</td>
<td>30-36, 83%-100%</td>
<td>Very High</td>
<td>Unique and Novel</td>
<td>I regularly come up with novel uses for things. (3)</td>
</tr>
<tr>
<td></td>
<td>22-29, 61%-80.5%</td>
<td>Moderately High</td>
<td></td>
<td>I come up with new and unusual ideas. (4)</td>
</tr>
<tr>
<td></td>
<td>18-21, 50%-58%</td>
<td>Average</td>
<td></td>
<td>I come up with unique suggestions, thought up wholly or partly independently of other people. (6)</td>
</tr>
<tr>
<td></td>
<td>14-17, 39%-47%</td>
<td>Low</td>
<td></td>
<td>I think in unconventional ways. (13)</td>
</tr>
<tr>
<td></td>
<td>0-13, 0%-36%</td>
<td>Very Low</td>
<td></td>
<td>I usually think out of the box. (20)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>I am very innovative. (29)</td>
</tr>
</tbody>
</table>
and instructor expectations regarding course outcomes. To begin to ascertain answers to the role of expectations I sent the following request to students in a graduate creativity course entitled Tools and Techniques in Creativity.

I am instituting a new feedback process to bring together learner and instructor expectations of what the student hopes to get out of a specific course and what the instructor hopes to have students get out of the course. In my role as a member of a university-wide committee looking at assessment of learning and teaching, I became aware that in general, we only deal with end-of-course evaluations. I also am aware that there is sometimes a disconnect between student and instructor expectations regarding course outcomes as well as mode of instruction. In keeping with the creative problem solving process, we must first identify the real problem (if one exists); namely, is there a disconnect between student and instructor expectations of course learning outcomes and pedagogy, and then proceed to generating solutions if indeed a disconnect exists. You all now have received the course syllabus, which specifies my expectations, and then we can see if there are any disconnects between our expectations as a first step to making adjustments.

So please respond directly to me via email the following:

What three most important learnings or skills do you expect to develop as a result of taking this course?

Some students expect a lecture format while the instructor is into an interactive student participatory pedagogy. This difference in pedagogical philosophy, i.e., the sage on the stage versus the teacher as facilitator, makes those students whose educational history had emphasized the student as responsible for his or her learning in a participatory model become bored and unresponsive in lecture pedagogy. At the same time, students with an educational history that emphasized lectures are initially uncomfortable in a teacher-as-facilitator learning environment.

Themes that emerged from the student expectations as a result of taking the course Tools and Techniques in Creativity involved enhancing creative problem solving skills; building on current professional, personal and educational experience by learning how to take a more creative approach; using new tools to promote creativity in working with supervisors and staff both in educational and corporate settings; and a few themes were quite personal: the course will help me to develop new and innovative ways to approach creative reasoning to very complex relationship issues that occur within my work team, develop new knowledge and skills that will help me move closer towards my goal of learning how to rebrand and repackage myself in the hopes of making creative problem solving in a corporate environment a career goal, and hope to be able to use the concepts of creative problem solving to improve my own personal life balance.

In this Handbook edited by Chunfang Zhou, it has assembled an array of authors from across the world who expertly address the challenges of infusing creativity into higher education learning and teaching. They discuss Problem Based Learning, Inquiry Based-based Learning, Design Thinking, Creative Problem Solving Skills, Developing Creative Learning Environments, Learning Technologies, and Managing Constraints.

Fredricka Reisman
Drexel University, USA
Fredricka Reisman, Ph.D., is professor and founding director of Drexel University’s School of Education, professor in the School of Education, Director of the Drexel/Torrance Center for Creativity and Innovation, and creator and former Program Director of the Creativity and Innovation Graduate and Undergraduate programs comprised of a master’s degree and a Creativity concentration in the Doctor of Education (Ed.D.) program. Additionally, Dr. Reisman served as Assistant Provost for Assessment and Evaluation and Interim Associate Dean for Research. Prior to coming to Philadelphia, Dr. Reisman served as Professor and Chair of the Division of Elementary Education at the University of Georgia and as an elementary, middle school, high school mathematics teacher in New York State, and mathematics education instructor at Syracuse University. She is the author of several books on diagnostic teaching, teaching mathematics to children with special needs, elementary education pedagogy, and mathematics pedagogy. She also has co-authored a trilogy of books with world-renowned creativity scholar and researcher, E. Paul Torrance, on teaching mathematics creatively. She has completed with co-author David Tanner (formerly Chief Innovation Officer at Dupont) a 2014 book entitled Creativity as a Bridge Between Education and Industry: Fostering New Innovations available from Amazon.com. Her team created a free Apple App (downloaded via iTunes) entitled the Reisman Diagnostic Creativity Assessment (RDCA), which taps 11 creativity research-based factors.
Preface

A key question in higher education field is how to foster students’ creative problem solving skills. It is due to the growing challenges in working practice where requires people to manage many complex and uncertain problems. Creativity is also required in the process of problem solving in diverse contexts such as applying the new scientific knowledge and using the new communication technologies. This encourages higher education to implement new teaching methods and educational technologies that are directed towards not only producing highly knowledgeable individuals but also stressing creative problem solving skills. These new methods and technologies have been explored in different disciplines in higher education including Engineering, Science, Business, Art, and Medicine, etc. So organizational changes are undergoing in institutions in higher education towards developing the problem-oriented curriculum and the creativity-integrated pedagogies. This brings challenges those are from aspects such as curriculum design, teaching and learning process, education technology, and assessment, etc. This calls for a systematic research on building relations between creativity, creative problem solving skills, and higher education research in order to meet the current knowledge gaps.

This handbook aims to address and discuss the context of higher education, the significance, difficulties and strategies in developing students’ creative problem-solving skills. The editor collected 24 chapters that present both new theories and experiences from diverse perspectives and cultures and by different research methods. Accordingly, the handbook contributes to provide an international platform to bring together academics, researchers, lectures, decision makers, and practitioners to share knowledge discussed and rethink how to develop students’ creative problem solving skills in the future.

Chapter 1, “Fostering Creative Problem Solvers in Higher Education: A Response to Complexity of Societies,” tries to emphasize that the complexity of professional practice has been recognized as the root of challenges for higher education. To foster creative problem solvers is a key response of higher education in order to meet such challenges. This chapter aims to illustrate how to understand 1) complexity as the nature of professional practice, 2) creative problem solving as the core skill in professional practice, 3) creativity as interplay between persons and environment, 4) higher education as the context of fostering creative problem solvers, and 5) some innovative strategies such as Problem-Based Learning (PBL) and building learning environment by Information Communication Technology (ICT) as potential strategies of creativity development. Accordingly, this chapter contributes to bridge complexity of societies, creative problem solving skills, and higher education development in one theoretical framework.

Chapter 2, “Thinking Inside the Box: Educating Leaders to Manage Constraints”, highlights that despite the importance of constraints in creative efforts has been recognized, little research examines the role of constraints in the creative process, how leaders manage these constraints, and implications for educating leaders of creative efforts. The present chapter synthesizes the literature on constraints and
leadership of creative efforts to provide an initial framework of constraints and creativity. Furthermore, this chapter proposes an initial model of constraint management portraying the cognitive and practical processes leaders engage in when managing constraints. The complexity and dynamic nature of constraints, as highlighted by the model, emphasizes the need for educational efforts specifically addressing constraint management in creative endeavors. Therefore, this chapter provides practical suggestions for educating future leaders in constraint management.

Chapter 3, “Scientific Creativity in Psychology: A Cognitive-Conative Approach”, argues that the aspired outcome of the present research consists in the investigation of the cognitive and conative profile underlying scientific creativity in psychology. In this purpose, an innovative creativity test adapted to the considered population was developed, including both divergent and convergent thinking. Whereas the analysis focused on intelligence in the cognitive domain, it focused on personality in the conative domain. The sample of psychology students consisted of 121 participants. Results stayed in line with the established hypotheses. Intelligence played the major role for scientific creativity in psychology. Concerning personality, openness and negative agreeability additionally favored scientific creativity in psychology. In future research, the profile of scientific creativity could be set into comparison to the one of artistic creativity and everyday creativity.

Chapter 4, “A Creativity and Innovation Course for Engineers”, introduces the teaching methodologies and pedagogical styles adopted within the “Creativity and Innovation”, offered at the University of Bologna, Italy, in the academic year 2014/2015. This course is taught by the Marconi Institute for Creativity (MIC) to graduate students in Telecommunications Engineering, and its main goal was to give students both a theoretical foundation and a hands-on experience about meta-cognitive strategies for controlling the thinking process towards the generation of new ideas. The students were engaged in the selection of a focus area within the range promoted by the call, creating the playground for team-oriented sessions in which relevant information was collected, divergent modifiers were applied, ideas were generated, and finally business models were sketched and assessed, to then conclude the course with a final presentation in front of a jury of three experts. The students’ feedback was very positive in terms of opening their minds to an activity that has no single “correct” answer, but rather a multitude of possibilities to be explored. While the ideational part of the class followed a learning-by-doing approach, this was preceded by a specific theoretical part, striking an effective balance between theory and practice.

Chapter 5, “Teaching Creative Problem Solving in Engineering Education”, presents the principles of active learning and the contents of a creativity course entitled: Creativity and Problem Solving. The main purpose of this course was to create a space for discussing, reflecting and experimenting with creativity, creative processes and creative methods of relevance for university students working with problem-solving approaches. This course was developed at the Technical University of Denmark during the period 1998-2008 for engineering students of various specialities. It started with very few students and developed to a very popular course attracting many students from abroad. The selected themes, the methods and techniques, the structure of the course, the learning processes and the achieved results can be applied to a similar course for university students of other fields such as IT, Management Sciences, System Sciences, Computer Sciences, Design, Agriculture, Business, Art and Education, etc. Finally some reflections, recommendations, and conclusions are also presented.

Chapter 6, “Creativity Development through Inquiry-Based Learning in Biomedical Sciences”, suggests that the increasing complexity of biomedical research has led to new models for collaborative research at large scale. Big science projects require multidisciplinary teams and skills, such as creativity, to foster innovation. Higher education can play an important role in fostering creativity with active-
Preface

learning strategies, such as the Inquiry-Based Learning (IBL) approach. In this chapter, we explain how the Universitat Pompeu Fabra (UPF) in Barcelona, Spain, used IBL to bring medicine and human biology students together to find creative solutions to solve a challenging problem in biomedicine. In this interprofessional experience, students were taught creative techniques in a creativity workshop. The positive results, which were highlighted by external evaluators for their high quality, demonstrate the value of these collaborative projects in encouraging creativity. We propose that integrating the IBL pedagogical methodology with creative techniques and interprofessionalism is a valuable approach for fostering students’ creativity and generative and research skills.

Chapter 7, “Distributed Problem-Solving: How Artists’ Participatory Strategies Can Inspire Creativity in Higher Education”, aims to deconstruct some persistent myths about creativity: the myth of individualism and of the genius. By looking at literature that approaches creativity as a participatory and distributed phenomenon and by bringing empirical evidence from artists’ studios, the author presents a perspective that is relevant to higher education. The focus here is on how artists solve problems in distributed paths, and on the elements of creative collaboration. Creative problem solving will be looked at as an ongoing dialogue that artists engage with themselves, with others, with recipients and with materials, in asynchronous or synchronous relationships. The empirical background draws on qualitative narratives collected in 2011-2014 and based on interviews with recognized artists. The questions guiding the present chapter are: If creativity does not arise from talent but from exercise and hard work, what can educators at higher education learn from the ways creative groups solve problems? How can artists contribute to inspiring higher education?

Chapter 8, “Creative Life Experiences among Students in Medical Education”, focuses on creativity and creative life experience of medical students in a university in China, in order to find out strategies of improving the medical students’ creativity. The methods such as literature review, participation, intervention, and questionnaire survey are used jointly in this study. The students are divided into experimental group and control group. A two-month creative psychological intervention is carried out with the experimental group, and the results show that the level of creative life experience factors of the experimental group was significantly higher than that of control group after the intervention, which indicates that appropriate creative psychological intervention has certain effect on improving university students’ creative life experience.

Chapter 9, “International Center for Studies in Creativity: Curricular Overview and Impact of Instruction on the Creative Problem-Solving Attitudes of Graduate Students”, provides an overview of the programs offered by the International Center for Studies in Creativity (ICSC) at Buffalo State University of New York, where creativity is taught and studied extensively at the graduate and undergraduate level. Following the discussion on creativity as a 21st century skill and perennial need for creativity in the workforce, programs and courses are introduced along with the historical roots and philosophy of creativity at ICSC. The models of Creative Problem Solving and Thinking Skills Model, which represent the core of the curriculum, are described. The chapter also presents the results of the study regarding the impact of the graduate program on the creative problem solving attitudes of the graduate students based on qualitative and quantitative data.

Chapter 10, “Problem Solving at the Edge of Disciplines”, outlines a new perspective on disciplinary collaboration that draws inspiration from ecology that observes that the edges where ecosystems meet tend to have greater biodiversity than the ecosystems themselves. This thinking is applied to a typical University Faculty consisting of three Schools to show that the potential for collaboration across disciplinary boundaries is rich. The chapter proposes a new degree structure that embeds problem-solving
skills as core to the production of “pi-shaped” people, defined as those that have disciplinary depth in two areas and the ability to work outside of their core area of expertise. In this regard, problem solving is considered as an area where a student can achieve depth of knowledge. The degree is designed such that it produces an exchange of students across disciplinary boundaries and also structured so that it takes students on a journey through different models of disciplinary collaboration. The degree is seen as a key enabled of achieving so called “Mode 2” knowledge production.

Chapter 11, “Enhancing Students’ Critical Thinking through Portfolios: Portfolio Content and Process of Use”, discusses that portfolios can serve a crucial role in helping students’ develop their critical thinking in writing, thereby promoting write-to-learn philosophy in education. Still, not any portfolio’s content and approach can guarantee the achievement of this goal. Teachers’ concern in promoting students’ critical thinking needs to be reflected in their decision that is related to the evidences of students’ needs that helps to select their approaches of integrating and using them into class. Students’ reflection needs to underpin all stages of portfolio assessment through providing opportunities for their decision-making, initiation and creativity. Therefore, this chapter puts forward a student portfolio model along with its content and process of use. This learning tool was integrated within the course of Written Expression and used by 33 students at the Department of English at Abdelhamid Ibn Badis University during the academic year 2013-2014. Recommendations are also provided in order to make it a vehicle for critical thinking.

Chapter 12, “An Exploration on Darkness within Doctoral Education: Creative Learning Approaches of Doctoral Students”, describes doctoral education also takes place on informal and tacit levels, where doctoral students learn about the institutional regulations, the research field, academic craftsmanship, and research design by observing how their supervisors talk, act, and handle issues in the professional community. However, the formal-informal divide is not adequate if we want to understand the sprawling, mongrel, and diverse forms of student engagement, coping, and learning strategies within doctoral education today. By drawing on the empirical studies of cross-level institutional voices, as well as international studies into similar grey areas of student learning in doctoral education, this chapter argues that learning spaces of educational ‘darkness’ hold unrecognized potential for enhancing learning experiences, harnessing professional competences, and enriching the depth of research in the PhD life that implies significant contributions to future doctoral education development.

Chapter 13, “Integrating Creative Problem Solving Skills into Higher Education Classroom”, introduces that the Torrance Incubation Model (TIM) provides a simple and highly effective mechanism for integrating creativity into the teaching of any subject. The model provides guidelines for educators who wish to develop their students’ creative skills, but struggle to find the space in the curriculum in which to teach creativity as a subject. The TIM allows creativity to be woven into lesson plans by deliberately incorporating one, or more, of the core creativity skills identified by Torrance. This chapter explains the TIM, and provides examples of how it was used to redesign lessons in a higher education class, in order to teach both the subject, and at the same time develop the students’ creative capabilities.

Chapter 14, “Design Thinking for Creative Problem Solving in Higher Education: How Students become Dedicated Creative Problem Solvers”, regards design thinking as an educational approach to enhance creative problem-solving skills. It is a problem-based learning paradigm that builds on three pillars: A creative problem solving process, creative workspaces and collaboration in multi-perspective teams. This chapter discusses central elements of design thinking education and contrasts the approach to conventional education as well as other problem-based learning paradigms. In particular, design thinking classes harness a unique “look and feel” and “verve” to help students acquire and experience
creative mastery. Furthermore, the chapter overviews empirical studies on design thinking education. Four studies are described in more detail: Experiments on the three pillars of design thinking and one case study where a university class curriculum has been changed to a design thinking paradigm. Finally, the chapter provides resources for readers who want to learn more about design thinking education.

Chapter 15, “Students’ Learning Experiences in Project-Based Learning (PtBL): With Pain Comes Gain”, examines the perceptions of nineteen graduate students’ regarding the incorporation of project-based learning (PtBL) in a Student Affairs class. This chapter demonstrates that not all students in the class were prepared to assume the responsibility of PtBL learning and yearned for a “traditional” classroom environment where instructors provide structure and step-by-step instructions. However, through hard work and the support from the instructor, the students were successful in completing outstanding PtBL workshops. While students reported increased levels of stress and anxiety while creating their workshop, students also reported having high levels of pride and validation once they successfully conducted it. Students reported being taken outside of their comfort zones and reported high levels of personal growth once they successfully completed their workshops. The PtBL research supports the assertion, “with pain comes gain”.

Chapter 16, “Advocating Problem-Based Learning and Creative Problem Solving Skills in Global Education”, advocates the development of Problem-Based Learning (PBL) and creative problem-solving skills in global education, thus describes the theoretical and practical overviews of PBL and creative problem-solving skills, the significance of PBL in global education, and the significance of creative problem-solving skills in global education. The application of PBL and creative problem-solving skills are critical in the educational institutions that seeks to serve the educational administrators and students, increase educational performance, sustain competitiveness, and fulfill expected accomplishment in global education. Therefore, it is required for educational institutions to utilize PBL and creative problem-solving skills towards satisfying the requirements of the educational administrators and students.

Chapter 17, “Instructional Design Technology in Higher Education System: Role and Impact on Developing Creative Learning Environments”, focus on how it is possible to facilitate better instructional experiences for the stakeholders in higher education. The chapter addresses the emergence of Instructional Design Technology (Chao, Saj & Hamilton, 2010). Its role and importance in higher educational institutions is analyzed with current practices in the field. The impact that this field had made in the evolution of instructional frameworks across the different layers of tertiary educational system is studied especially with regard to improving the teaching and learning experiences of educators and students respectively. The importance that institutions pay to instructional design is reviewed by a case study. Any technology needs to adapt to the requirements of the age. The role of adaptive Learning technologies’ is studied with emphasis on the success that these systems have enjoyed in improving instructional design. Universities are going to have business intelligent systems while going for instruction designing and deciding learning strategies.

Chapter 18, “Developing Creative Problem Solvers and Professional Identity by Information Technology Communication (ICT) in Higher Education”, regards creative problem solving as a professional identity skill that can be fostered by creative learning environments supported by Information and Communication Technology (ICT). A systematic literature review will be provided in order to build relationships between creative problem solving, creative learning environments, ICT, and professional identity in the context of higher education. The literature review will focus on the following research questions: How do ICTs support a creative learning environment in fostering creative problem solving
skills? How do ICTs relate to or affect the characteristics of professional identity in the context of higher education? And how do ICTs relate to or affect the formation of professional identity in the context of higher education? These three questions will help allow to organize the structure of this chapter that drive the authors to propose a change of perspective in the study of professional identity and ICT, from the theoretical standpoint of actor-network theory.

Chapter 19, “Reaching ‘Creating’ in Bloom’s Taxonomy: The Merging of Heutagogy and Technology in Online Learning”, emphasizes that Creativity of thought and critical thinking are two concepts that faculty struggle with teaching in higher education, particularly in the distance learning environment. Bloom’s taxonomy has been used to define taxonomic levels in learning since the 1950’s; “create” is one of its highest taxonomic levels. It can be difficult to create relevant, authentic assessments that require students to display both synthesis of meaning, as well creative synthesis of concepts learned to reach this “create” level in an effective manner. Transformative learning and especially heutagogy or “self-determined learning” can be used as theoretical curriculum models or frameworks to help students learn and solve problems. These two theories are particularly effective when leveraged with technology. Today’s instructional technologies allow students to more readily create and explore new concepts on their own to generate a more fulfilling education process with meaningful relevant practice and assessment.

Chapter 20, “Applying Blooms Digital Taxonomy to Address Creativity and Second Order Digital Divide in Internet Skills”, suggests that Internet technologies play a significant role to enhance creativity of the students in learning environments. Internet literacy is vital to effectively use the Internet tools to enhance creative learning environments. In the developing countries Internet literacy is still an unfulfilled dream for students coming from underprivileged backgrounds thus bringing a digital divide in skills. The chapter draws upon an empirical study done in India on how an intervention comprised of Internet training designed on Bloom’s Digital Taxonomy and action research workshops based on the learning domains of the digital taxonomy was an effective approach for empowering women students through learning to use the Internet. The chapter puts forward the argument that an intervention for learning to use the Internet can be effective where focus is on the reflective and conceptual skills in using the Internet than focusing too much on the content that is dynamic.

Chapter 21, “Creative Problem Framing in Higher Education”, re-examines conventional views of problems in the context of creativity those indicating can be “solved” creatively, and argue that such views are misleading notions, as problem-finding and problem-framing are more appropriate and relevant issues to be focused in the study, practice, and teaching of creativity. The chapter continues Section 2 with a review of key ideas from the literature. In Section 3, the formulation and reformulation of problems is analyzed by considering a collection of real cases where the authors have been directly involved. These cases illustrate a wide diversity of types of reformulation processes. A specific case is described at length, inspecting in detail the issues related to reframing creative problems. The chapter ends with a discussion of the pedagogical issues needed to support the development of Creative Problem Framing (CPF) in Higher Education.

Chapter 22, “On Relationships between Creative Learning, Creative Teaching, and Roles of Creative Teachers”, discusses the relationships between creative teaching, creative learning and the role played by creative teachers in the contexts of students’ creativity development. Firstly, this chapter analyzed the characteristics of creative teaching and creative learning. The history of the research on creative teaching and learning since the first half of 20th century was briefly introduced. Secondly, the authors discussed the nature of creative teaching, the features of creative teachers compared to non-creative teachers, the environment for the development of creative teachers and the measures that should be taken to promote
the growth of creative teachers. Accordingly, this chapter contributes to development of creativity in higher education both theoretically and practically in the future.

Chapter 23, “New Paradigm of Creativity: From Newtonian Mechanics to Quantum Mechanics and Higher Education Development”, provides an alternative perspective on creativity in order to accelerate a paradigm shift in creativity in higher education. The perspective would enable every single person to extract the full potential and to contribute to society. Due to the idea of science: reproducibility, the main goal of research has been finding an ultimate solution that would be applicable to every single person. This idea comes from Newtonian mechanics; or, in other words, cause and result relation, that a specific factor causes a specific outcome. The problem of this idea is that Newtonian mechanics is designed for such objects as an apple and a car. Obviously, human thought, the main source of creativity, is not an object. This fact suggests the necessity of alternative approach. The author proposes a different perspective to change a paradigm of creativity in higher education.

Chapter 24, “Going towards Adaption, Integration, and Co-Creation: A Conclusion of Developing Creative Problem Solving Skills in Higher Education”, serves as a conclusion chapter. It highlights that as a response to growing challenges brought by complexity in professional practice, the collection of chapters in this volume guides an intellectual journey through the various theoretical perspectives, research methods and pedagogical models with a focus of developing creative problem solving skills in higher education. Based on an overview of topics in this volume, this chapter aims to draw a conclusion of research directions in future exploration from present presentations. It could be an extended journey with an intention to help audience to locate the ideas presented in this volume within a framework constructed by three main themes of adaption, integration and co-creation. This lays a stepping-stone in paving the way of pedagogical development and research prospects.

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Section 1

Point of Departure
Chapter 1

Fostering Creative Problem Solvers in Higher Education: A Response to Complexity of Societies

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ABSTRACT

Recent studies have emphasized issues of social emergence based on thinking of societies as complex systems. The complexity of professional practice has been recognized as the root of challenges for higher education. To foster creative problem solvers is a key response of higher education in order to meet such challenges. This chapter aims to illustrate how to understand: 1) complexity as the nature of professional practice; 2) creative problem solving as the core skill in professional practice; 3) creativity as interplay between persons and their environment; 4) higher education as the context of fostering creative problem solvers; and 5) some innovative strategies such as Problem-Based Learning (PBL) and building a learning environment by Information Communication Technology (ICT) as potential strategies of creativity development. Accordingly, this chapter contributes to bridge the complexity of societies, creative problem solving skills, and higher education development in one theoretical framework.

COMPLEXITY AS NATURE OF PROFESSIONAL PRACTICE

The complexity of the world is increasing and it has become a popular term in current discussion. Schloemer and Tomaschek (2010) argue that the emerging complexity brings massive changes in economics and markets that require companies to change swiftly too. In the book Social Emergence: Societies as Complex Systems, Sawyer (2005) argues that societies are complex dynamic systems and that it is necessary to develop the concept of emergence, focusing on multiple levels of analysis—individuals, interactions, and groups—of how social group phenomena emerge from communication processes among individual members. There are also studies in fields such as management (Lissack, 1999) and education (Haggis, 2004). Undoubtedly, emergence is a valuable topic to be explored and theories of complexity are fundamentally interdisciplinary and are of contemporary interest in many areas (Tosey, 2006).

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However, how to understand complexity theory and what does the emergence mean? According to Tosey (2006), complexity theory refers to a cluster of ways of thinking that have developed over the past decades from branches of ‘new science’ concerned with the behavior of nature systems, such as chaos theory, dissipative structure theory, and quantum physics. It offers a way of thinking about human systems. Basically, a complex system means a system whose perceived complicated behaviors can be attributed to one or more of the following characteristics: a large number of elements; a large number of relationships among elements; non-linear and discontinuous relationships; and uncertain characteristics of elements (Zhou, 2012). This demonstrates a shift in thinking from seeing parts to seeing systems of parts, recognizing that the interaction of those parts is not static and constant, but a dynamic process (Calvano & John, 2004). Complexity refers to the condition of the universe that is integrated and yet too rich and varied for human beings to understand in simple common mechanistic or linear ways. Although many parts of the universe can be understood in these ways, the larger and more intricately related phenomena can only be understood by principles and patterns—not in detail. So complexity treats human systems as directly analogous to nature, which is rarely predicable and linear. This means human systems appear to display many of the characteristics of complex adaptive systems. In particular, coherent patterns of behavior can arise from the apparently idiosyncratic interactions of random individuals (Tosey, 2006).

The property of complex systems, a phenomenon known as emergence, is highly significant. Theories of emergence have influenced psychological theory since the beginning of the field in the late nineteenth century. Emergentism in psychology has its roots in nineteenth century organicism: the theory that the organism is different from the sum of its parts and that it depends on the structural arrangement of those parts. Social organicism—the notion that society forms an integrated unity similar in some sense to that of living organisms—can be traced to classical social philosophy, but the publication of Darwin’s account of evolution gave new energy to social organicistic theories (Giddens, 1970). In the nineteenth century, organicism was prominent in German social philosophy; influential advocates included Schäffle and Lilienfeld (Sawyer, 2003). These theories influenced German psychologists, including Wundt and the early Gestaltists. So, evolutionary and organicist thinking were strong influences on psychology’s founders. This further influenced later researchers who are working as neurologists, evolutionary biologists, and materialists (Sawyer, 2003). However, the emergentists rejected mechanistic theories that held that the behavior the whole could, in theory at least, be deduced from a sufficient knowledge of how the components behave in isolation or in other wholes of a simpler kind (Broad, 1925). Based on the work of Kim (1992) and Teller (1992), Sawyer (2003) summarized the following claims:

- There are basic, non-emergent entities and properties, and these are material entities and their properties.
- Emergence is a process that occurs over time.
- When aggregates of basic entities attain a certain level of structural complexity, properties of the aggregate emerge. New stuff does not emerge; rather, it is properties of the higher level entities that emerge.
- What emerges is a new level of reality corresponding to evolutionary or historical stages.
- Because these properties are properties of complex organizations of matter, they emerge only when the appropriate lower level material conditions are present.
- What emerges is novel; it did not exist before the process of emergence.
- What emerges is unpredictable, and could not have been known analytically before it emerged.
• Emergent properties are irreducible to properties of their lower level parts, even though they are determined by those parts.

Accordingly, emergence refers to the process by which patterns or global level structures arise from interactive local level processes. This ‘structure’ or ‘pattern’ cannot be understood or predicted from the behavior or properties of the component units alone. It involves unpredictability, new forms coming out of apparently disconnected, even irrelevant, thoughts and sensations, and an inability to force or control the outcome; however, it does not seem to be a completely random thing (Tosey, 2006). Drawing on the previous work of researchers such as Richard Seel (2002, 2005), a list of conditions for facilitating emergence has been described as follows (Tosey, 2006).

• **Connectivity:** Emergence is unlikely to occur in a fragmented world.
• **Diversity:** If there is not enough diversity in the system, it will be hard for different patterns to emerge.
• **Rate of Information Flow:** Either information overload or too little information flow can make emergence unlikely.
• **Lack of Inhibitors:** For example, inappropriate power differentials, too much anxiety or threats to identity can all inhibit emergence.
• **Good Constraints to Action:** Effective boundaries can enhance the possibility of emergence.
• **Positive Intention:** A clear sense of purpose can influence the chances of emergence occurring.
• **Watchful Anticipation:** While a clear sense of purpose can influence the chances of emergence occurring, a period of expectant waiting is often necessary to facilitate emergence.

Complexity theory and the concept of emergence offer a radical and innovative frame for understanding the nature of professional practice, particularly away from the idea that leaders, managers, or employees are in control. For example, in the field of engineering, what engineers are being asked is to learn to keep expanding along with the scope and complexity of the hybrid world. Engineering has evolved into an open-ended profession of everything in a world where technology merges into society, into art and into management, with no strong sense of an overarching mission. All forces that are pulling engineering in different directions—towards science, towards market, towards design, towards systems, towards socialization—bring professional challenges to engineers. In the workplace, the knowledge that engineers draw on is increasingly dynamic and complex. Engineers must not only stay informed about new and emerging technologies, but must also be aware of knowledge skills from other domains. Thus, types of knowledge that engineers bring to bear in their work are wide-ranging (Zhou, 2012). Engineering is similar to any other fields in that, as described by Dörner (1979), there are two typical characteristics of problem solving in professional practice: complexity and uncertainty. Complexity means many components are involved and these components, through links of different strengths, influence one another, while uncertainty means not all requirements are known, not all criteria are established. The effect of a partial solution on the overall solution or on other partial solutions is not fully understood, or only emerges gradually. The difficulties become more pronounced if the characteristics of the problem area change over time (Zhou, 2012). This indicates that any profession is not an instrumental process and is full of ambiguity. There is neither a routine solution nor a defined script for doing the work.

In particular, this reflects that higher education institutions and the people they employ are confronted daily by continuous change. This also drives us to rethink the question ‘what is education for?’ Advocates
of a biological analogy propose that education is for the well-being and development of society and is directed by requests from professional practice. Durkheim (1956) argued that education served three main functions: 1) reinforcing social solidarity through subject context and through shared rituals; 2) transmission of norms and values—social roles and social stability are reproduced through replication of hierarchies and social expectations; and 3) the young are exposed to variety of skills, and the extent to which they show aptitude in these directs them towards suitable employment and maintains the social division of labor (Leighton, 2011). This has also driven discussions on education from an economical perspective (Vignoles, 2011): educational investment makes a contribution to a country’s economic growth just as it does to individuals’ wages, though it is not simply the average educational level of the workforce that matters for economic growth, but rather the quality of education acquired and the actual skills gained by workers. As Oancea (2011) argued, one of the key contributions of education research is to social and political aspects of educational institutions, learning environments, educative practices, and education reform (such as liberal and vocational education, the common school, democracy and citizenship, power, authority, parents’ and children’s rights, equality, diversity, inclusion, fairness and justice, caring, oppression, accountability, quality, and the role of education in social change). In addition, in contemporary philosophy there is a strand of thinking suggesting that the very idea of the university is under threat from the force of globalization. While the university in all national contexts faces pressure to be or become more economically efficient and ‘relevant’, the counter-discourse seeks to reclaim the special educational role of the university against the dominance of ‘technological enframing’. Such discourses have seriously questioned the proliferating tendency to orient research and teaching towards a programmable and profitable end (Peim, 2011).

Therefore, higher education institutions can be conceived of as ever-changing conversations, patterns of gesture and response, meaning and commitment. As indicated by a complexity perspective (Stacey, 2001), organizations are best described as patterns of ‘complex responsive processes’, such that human futures are under perpetual construction through the detail of interactions between human bodies in the living present. If these interactions are rich and diverse, novel forms may emerge and enable creative and adaptive change. If not, the institution may be doomed to repeat itself until it is so far out of alignment with its environment that it starts to exist within a time warp. The propensity of these conversations to generate novelty is crucial (Tosey, 2006), which indicates there has never been a greater apparent need for creativity in higher education in order to accomplish complex change while maintaining quality and standards.

CREATIVE PROBLEM SOLVING AS CORE OF PROFESSIONAL PRACTICE

What is a problem? It can be defined as a wondering which takes the concrete form of a question; it can be characterized as the discrepancy between a hypothetical normal condition and a fact which diverges from it; it is a form of appearance for contrasts, conflicts and contradictions (Qvist, 2004). So the problems themselves are usually described as being complex. By taking engineering practice as an example, Zhou (2012) suggested that it is separate from problems in which the number of variables is severely constrained, and problems can be solved by the use of knowledge and techniques common to all involved and towards a ‘complex system’ that is so heterogeneous that interdisciplinary interactive groups sharing perspectives and information are needed to create and control them. There is a series of constraints on the solutions that those engineers have to consider when they are solving the problem,
such as technical function, economic feasibility, safety requirements, ethical issues, and resource considerations, etc. Christensen (2004) describes there are two types of problem. A practical problem can be said to exist when a phenomenon which influences our living conditions, either socially or technically, is experienced as being ‘wrong’, ‘bad’, or ‘unsatisfying’. A practical problem may also appear as a dilemma. A theoretical problem can be said to exist when a wonder emerges at the character or the background of a phenomenon. Therefore, finding, working with, and solving problems is always embedded in all professional practice.

To solve a problem requires creativity; meanwhile, problems are sources for developing creativity. According to the literature, a general definition of creativity is the development of new and useful ideas (Sternberg, 1999). The creative act may be regarded either as a mental or an intellectual phenomenon, known as creative thinking or divergent thinking, or as a process that generates social and cultural products, such as music and works of art, science and technology, a concept known as divergent production (Guilford, 1950). Thus, creativity is both a domain-general and a domain-specific ability (Kaufman & Bare, 2005). Furthermore, ‘newness’ is pointed out as being new with regard to the whole of humanity or to the person’s previous ways of thinking; ‘usefulness’ means to possess relevance and effectiveness and having the ability to satisfy the need for which it is created. There are also discussions on the relevance of ‘originality’, ‘inventiveness’, and ‘effectiveness’ within creativity (Zhou, 2012). So, it is argued that creativity is included in a number of interdependent and interactive capacities in solving and analyzing problems (Rugarcia et al., 2000). For example, Cropley and Cropley (2005) provided a definition of engineering creativity which described that the most important characteristic is to perform tasks or solve problems. In solving problems, any new and useful ideas could be potential solutions; the value of creativity could be helpful for solving problems, whereas we also could accept problem solving as one kind of creativity (Rubinstein, 1974). Furthermore, in professional practice, problems can take various forms, such as failure to perform, situations in need of immediate attention or improvement, a need to find better ways to do things, unexplained phenomena or observations, gaps in information and knowledge, decision-making situations, or a need for new designs or innovations. A problem triggers the context for engagement, curiosity, inquiry, and a quest to address a real-world concern. These psychological events, in turn, set in motion certain mental processes and behavioral changes, which includes developing creative ideas (Tan et al., 2009). In this sense, ‘creativity’ and ‘creative problem solving’ can be as interchangeable terms. For example, in the work of Basadur (1994), organizational behavior can be described as a three-stage process of problem finding, problem solving, and solution implementation activity. This process should be identified as a complete process of creative problem solving. In other words, nothing creative has happened until something ‘gets done’.

There have been increasing calls for creativity in everyday life—otherwise described as life-wide creativity (Craft, 2002) or life-wide resourcefulness in charting a course of action by seeing opportunities as well as overcoming obstacles. While someone may have a new idea about how to run a country or a company, artists may develop new types of music, and scientists may develop new techniques or knowledge that may have a profound impact on society. This type of creativity has sometimes been called ‘big C’ creativity. The everyday creativity has been described as ‘little C’ creativity that happens as people try to solve problems at work and at home, or on the road in between (Paulus & Nijstad, 2003). In other words, ‘little C’ creativity may occur in personal and social matters or in undertaking an activity in a disciplinary or professional area. It is ‘know-how’, concerned with the skills involved in maneuvering and operating concepts and ideas in the physical and social world—including the skills of social interaction and engagement (Craft, 2006). So there are economic, social and cultural arguments as to why
creativity should be a prized asset. Creativity is becoming a key resource for individuals and societies. It will enable people to make the most of new opportunities, and to find the most productive responses to challenges as well as threats (Smith-Bingham, 2006). As suggested by Isaken (1983), the need for people skilled to help others use creative problem solving is increasing. For example, The Engineer of 2020 (National Academy of Engineering, 2004) points out that engineers need ‘creativity’—that is, the ability to respond to challenges by combining in new ways a broader range of interdisciplinary knowledge, and a greater focus on systemic constructs and outcomes (Zhou, 2012). In short, creativity is a means of envisaging solutions and ways forward, of thriving in a complex social system with numerous different needs (Smith-Bingham, 2006).

Moreover, the term ‘creative problem solving’, or CPS, is most often discussed as a thinking skills model. CPS is a ‘toolkit’ approach to creative thinking which often frustrates those people who believe that there is no way that you can ‘teach’ creativity but that is an inherent quality in a person. However, the tools are based on ways of thinking and following much practical research about what seems to work in helping people make lateral connections or interesting associations in their thoughts. A popular creative thinking exercise is to follow stages, including 1) preparation, 2) question formulation, clarification and reformulation, 3) purge, idea generation and incubation, and 4) idea clustering, evaluation and action planning. By using this approach, one soon may realize one’s potential in ‘thinking outside the box’. Once individuals or groups become used to some of the thinking suggested by the tools, they no longer need them and even develop their own tools (Baillie, 2006). Based on the previous work, Puccio and Cabra (2014) provided a summary of thinking skills and their respective steps for CPS:

- **Diagnostic Thinking (Assessing the Situation):** Making a careful examination of the situation, describing the nature of the problem, and making decisions about appropriate process steps to be taken (curiosity).
- **Visionary Thinking (Exploring the Vision):** Articulating a vivid image of what you desire to create (dreaming).
- **Strategic Thinking (Formulating Challenges):** Identifying the critical issues that must be addressed and pathways needed to move towards the desired future (sensing gaps).
- **Ideational Thinking (Exploring Ideas):** Producing original mental images and thoughts that respond to important challenges (playfulness).
- **Evaluative Thinking (Formulating Solutions):** Assessing the reasonableness and quality of ideas in order to develop workable solutions (avoiding premature closure).
- **Contextual Thinking (Exploring Acceptance):** Understanding the interrelated conditions and circumstances that will support or hinder success (sensitivity to environment).
- **Tactical Thinking (Formulating a Plan):** Devising a plan that includes specific and measurable steps for attaining a desired end and methods for monitoring its effectiveness (tolerance of risks).

In addition, Puccio and Cabra (2014) highlighted that CPS is not designed to replace individuals’ natural creative thinking processes, but to explicate this process in a way that allows them to be more systematic in how they approach challenges. Thinking is not always neat and orderly; thus the CPS model attempts to introduce structured thinking into our more intuitive creative attempts in a way that enhances effectiveness and increases the likelihood of producing novel solutions to perplexing problems. So, Buijis et al. (2009) described that the model of CPS has been employed broadly in organizations to improve creative products and in educational contexts to enhance students’ creative thinking skills. This model
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has a trajectory of development from the classical linear five stages of “fact finding, problem finding, idea finding, solution finding and acceptance finding” to a systematic ecological model highlighting interactions of “ideas, action and practice”.

CREATIVITY AS INTERPLAY BETWEEN PERSONS AND ENVIRONMENT

As indicated above, creativity is an essential feature of our lives. Everybody can be creative to some extent. However, one of the problems with creativity is that it is difficult to understand and explain. But creative abilities do not stand in isolation: they have to be blended and connected to other sorts of ability and capacity. Indeed, the act of blending and utilizing different abilities, knowledge and capacities to achieve a goal is itself a creative act. As suggested by Sternberg and Lubart (1995), successfully intelligent individuals succeed in part because they achieve a functional balance among a ‘triarchy’ of abilities: analytical abilities, which are used to analyze, evaluate, judge, compare and contrast; creative abilities, which are used to create, invent, discover and imagine; and practical abilities, which are used to apply, utilize, implement and activate. Successful intelligent people are not necessarily high in all three abilities, but find a way to exploit effectively whatever patterns of abilities they may have. Jackson and Sinclair (2006) suggest the following features of creativity and creative people:

- Being imaginative; generating new ideas; thinking outside of the boxes we normally inhabit; looking beyond the obvious; seeing the world in different ways so that it can be explored and understood better.
- Being original. This embodies:
  - The Quality of Newness: For example, inventing and producing new things or adapting things that someone else has invented; doing things no one has done before; doing things that have been done before but differently;
  - The Idea of Significance: There are different levels and notions of significance, but utility and value are integral to the idea.
- Exploring, experimenting and taking risks—i.e. processes for searching in order to find or discover often involve journeying into the unknown.
- Skills in critical thinking and synthesis—the ability to process and analyze data/situations/ideas/contexts and to see the world differently as a result.
- Communication—often through storytelling that helps people see the world you have created or helps you see the worlds of others.

Undoubtedly, creativity involves some knowledge. According to Craft (2005), whichever approach to learning one adopts as dominant in the foundations of one’s practice, creativity can be seen as, effectively, offering students opportunities to shape new knowledge. When students learn something new, they are making new connections between ideas and making sense of them for themselves, and they are constructing knowledge; in this sense it could perhaps be described that what students are doing is being creative. However, shaping new knowledge cannot occur without some understanding of what already exists, and without opportunities to engage with this and take it to a new place (Craft, 2005). In other words, creativity cannot appear without a knowledge context provided by certain domains and social practice. ‘Social practice’, using the notion of Wenger (1998), includes both the explicit and the tacit,
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and our communities of practice are places where we develop, negotiate, and share them. To analyze creativity development in settings of group learning should therefore take into consideration the stimulus of the social practice of learning to learn from the tacit to explicit level. There are also discussions focusing on relationships between creativity and knowledge, aiming to make further efforts to search for an appropriate pedagogy to foster creative thinking or greater deep learning (Jackson & Sinclair, 2006).

Creativity also goes beyond ‘doing it differently’, ‘finding alternatives’ or ‘producing novelty’, for it involves having some grasp of the domain and thus of how the ideas relate to existing ones. It does not necessarily result in a product outcome, but always involves a process. It involves the use of imagination, intelligence, self-creation and self-expression (Craft, 2006). Thompson and Lordan (1999) outlined four special focuses (4Ps) in studies on creativity, which include 1) the person, 2) the process, 3) the product, and 4) the place. Recent insights have emphasized that any creative behavior happens in the interplay between at least these four focuses. As Mumford, Reiter-Palmon and Redmond (1994) argued, there are a host of variables influencing the nature and ontogeny of the creative act. These variables span a wide range of individual and situational attributes, including knowledge, basic cognitive processes, aptitudes and abilities, personality characteristics, environmental perceptions, environmental structure, cultural characteristics, and economic or evaluative considerations. Although there is relative uncertainty as to the essence of creativity itself, one may understand the concept by means of studying the influencing factors that interact with each other continually (Zhou, 2012).

Accordingly, a variety of social approaches have provided powerful evidence of shaping the role of context in creativity (Runco, 2007). As concluded by Sternberg (1999), the development of scientific thinking about creativity has followed a trajectory that had an early emphasis upon isolated individuals and their internal traits and capabilities, followed by a developing focus upon the interaction between individuals and their environment. Craft (2006) also argued that, since the 1990s, the methodology for investigating creativity in education has also shifted, from large-scale studies aiming to measure creativity, toward ethnographic, qualitative approaches to research focusing on the actual site of operations and practice, again situating creativity in specifics of the underlying disciplines, and in the social and cultural values and practices of particular settings. Thus, researchers have shifted their focuses from “what creativity is” to more “where creativity happens”. This shift drives us to further clarify the following characteristics of creativity by considering “where” (Zhou, 2012).

- **Creativity in the Mind:** As argued by “person” (cognitive or psychological) approaches, any creative idea is generated from a cognitive process in the mind. The basic cognitive process (e.g., attention, perception, memory, information processing) and individual differences (e.g., intelligence, language, personality style) have close connections with creativity.

- **Creativity in Collaboration:** Creativity is generated from a collaborative process beyond the individuals, which is defined as group creativity. It focuses on interpersonal interactions, as one kind of social influence which can be found in the various evidences of collaborative efforts demonstrates that collaboration involves an intricate blend of skills, temperaments, efforts and sometimes personalities to realize a shared vision of something new and useful (Sawyer, 2007); or as emerging through dialogue and “being in a relationship”, which is seen as the dynamic interaction from a constructivist framework.

- **Creativity in the Social System:** Social influences (e.g., social structure, economy, culture, religion, policy, community, organization, family) are taken into account. This is because social
processes and structures represent such dramatic influences on creativity and they can support, undermine, or neither support nor undermine each other’s creativity.

The shift (from “what” to “where”) in studies and the redefinition from a ‘where’ perspective are basically in line with what Craft (2006) argued were the changed emphases on 1) ordinary creativity rather than genius; 2) characterizing rather than measuring; 3) the social system rather than the individual; and 4) encompassing views of creativity that include products but do not see these as necessary. This also further underpins a sociocultural perspective to creativity, as sociocultural theory posits that intellectual development is achieved through dialogue and that creativity can be described as an interaction between characteristics in people and communities, creative processes, subject domains and the wider social and cultural context (Loveless, Burton, & Turvey, 2006). Csikszentmihalyi (1996) proposed that creativity arises from the interaction between the ‘intelligence’ of individuals, the domain or areas of human endeavor, disciplines, crafts or pursuits, and the field, such as people, institutions, award mechanisms and ‘knowledgeable others’, through which judgments of individual performances in society are made. The levels of achievement of originality for individuals, peer groups or within the domain are evaluated within the field, whilst the judgment of value can relate to critical reflection in the individual as well as recognition of a unique contribution to the domain itself. Creativity can therefore be seen in the interaction between a person’s thoughts and actions, as individuals and in communities, in their knowledge and skills within a domain and within mediating cultural tools, and in a sociocultural context which can encourage, evaluate and reward. This has important implications for thinking about creativity, where the learning environment might either nurture or dismiss the development of creative individuals, groups and communities (Loveless, Burton, & Turvey, 2006).

So creativity should be regarded as being social and collaborative and happening through interactions between persons. Grossen (2000) suggested that the characteristics of the task, its social and personal meaning for the subjects, and the activity in which the task takes place, are all elements which frame and orient the subjects’ interactions. Roja-Drummond et al. (2008) argued that the micro-context of the interaction is related to other contexts—the institutional context of a school, for example—and, more broadly, the cultural practices at work outside the school. In collaborative settings particularly, group interaction can provide a basis for the exchange of information among group members. In addition, to develop novel ideas requires a certain degree of knowledge and experience, a willingness to take risks or take unique perspectives, and a style of bringing together diverse or previously unconnected domains. From the various ideas that are generated, the most useful ones must be selected and then promoted to gain social acceptance (Grossen, 2008).

HIGHER EDUCATION AS A CONTEXT FOR FOSTERING CREATIVITY

Tosey (2006) argues that some connotations of ‘creativity’, such as imagination, originality, unorthodoxy and fantasy, appear in tension with important cultural values in higher education of respectability and rigor in knowledge generation, and with the need for conformity, standardization, accountability and risk aversion in institutions. While generating the outputs expected of creativity development in higher education undoubtedly involves a creative process, it is perhaps regarded more as a subset of innovation. However, discussions on creativity often focus on how individuals can be more creative. Why can our people not be more innovative, or take more initiative? Why are the ideas coming forward for research
or development projects so lacking in imagination? The perspective of complexity is more that creativity is latent or inherent in human systems. We all dream and we all make mistakes, but can we create and sustain conditions in which that capacity can flourish?

Recent research has responded to the above concerns and increased the level of attention paid to the environmental conditions for fostering creative problem skills. For example, Felder (1998) argued that creative problem solving is an ability that we must exercise and augment in our students through providing a suitable environment and by using effective exercises. These exercises should encourage creative thinking by having divergent (multiple) solutions, or potentially no solution at all. He also advocates the use of open-ended questions, where students have to define what they need to solve, and the use of brainstorming and other techniques where students are encouraged to think of as many ways to achieve a specific task as possible. Teachers’ pedagogic strategies and attitudes can also have an impact on creativity. Teachers who see themselves as the ultimate authority and expect obedience and respect rather than challenges from students won’t be able to inspire students’ creative thinking well. On the other hand, if teachers work from the assumption that their role is to help every student reach their inner potential, they will encourage and reward creative behavior in learning (Ng, 2003). Kazerounian and Foley (2007) propose a list of ten factors—called the ‘maxims of creativity in education’—that constitute an educational environment conducive to fostering creativity. The maxims are: 1) keep an open mind; 2) ambiguity is good; 3) creativity is an iterative process that includes idea incubation; 4) reward creativity; 5) lead by example; 6) learn to fail; 7) encourage risk; 8) search for multiple answers; 9) internal motivation; and 10) ownership of learning. Similarly, Richards (1998) suggests strategies such as 1) don’t be afraid to be different; 2) be open and receptive to new ideas; 3) relax; 4) reflect; and 5) have fun, etc. Jackson and Sinclair (2006) suggested developing effective teaching and learning systems by consideration of the complexity of factors and interactions that influence students’ creativity, so the complex interactions and interdependencies between teacher, learner and task have also been highlighted. In terms of teacher activity in such an effective teaching and learning system, it should be organized by any approach or motivation towards a task or learning in general that is dependent on the teacher’s mode of presentation of the academic tasks/learning processes/reflective approaches, and consolidated through the following:

- Appropriate structuring of knowledge bases, dependent on a detailed knowledge of academic content to be learned.
- Attention to appropriate learning strategies for students, dependent on a knowledge of cognitive and metacognitive processes and how learners can be encouraged to use these.
- Ability to predict and deal with the variety of students’ cognitive abilities, motivations, etc.
- Ability to demonstrate and model approaches to required outcomes.
- Ability to promote thinking through questioning and challenging.
- Attention to written instructions and examples that reinforce spoken instructions.
- Providing timely feedback, verbal and/or written, or computer-based.
- Ability to match assessment to intended learning outcomes.

Therefore emphasis in teaching for creativity should be put on a systematic view to creativity that involves interactions between the 4Ps (Zhou, 2012) and on constructing teaching and learning environments conducive to the development and expression of creativity (Zhou, 2014). For example, a three-element creative pedagogy framework is proposed by Lin (2011), that offers a more holistic view of enhancing creativity though the interplay between creative teaching, teaching for creativity, and creative learning.
Similarly, Tanggaard (2014) proposed a situated model of creative learning that is based on three key concepts: 1) immersion in the topic of interest, in traditions and in the subject matter; 2) experimentation and inquiry learning; and 3) position to the material of interest. Craft (2006) argued that a situated perspective sees creativity learning as an apprenticeship, with a central role being given to the expert adult offering induction to the relative novice. This emphasizes the intention for young people to take ownership of ideas, processes, and directions, and to engage with motivation in their own creative journey. However, an apprenticeship is finite. Ultimately the novice becomes a newly fledged expert, letting go of the edges, standing alone without the scaffolding, making their own map. Creative practitioners who are particularly skilled are sensitive to when it is appropriate to encourage young people to move to the edge of, and then beyond, the scaffolding. Cropley (1999) also concluded various learning methods that can be applied in the classroom in all disciplines and at all age levels that focus not only on thinking skills but also on motivation, attitudes, and personal characteristics. These methods include:

1. **Discovery Learning**: Working alone or in small groups, students examine contents to discover hidden or unexpected connections or structures, either physically or, more usually, in the form of recurring regularities, categories, rules, or irregularities, problems, and the like.

2. **Play Learning**: Play is free of the constraints of the strictly logical. Risks can be taken without fear of real life consequences; rules can be broken, the impossible can be tried out, and fantasy can be given free rein.

3. **Learning via Problem Solving**: A gap, difficulty, or open question is the starting point for the learning. The problem has to be defined, relevant information collected, and solutions suggested. The suggestions can be developed in a play-like atmosphere with the advantages listed above, or they may be required to be strictly reality oriented.

4. **Learning via Structural Analysis**: A given situation has to be broken down into its constituent elements (in some ways, the opposite of discovery learning), and the rules or principles of its structure identified. Suggestions, including fanciful ones, can then be made for ways to change elements or their connections with one another.

Furthermore, McWilliam and Dawson (2008) discussed the shift in teaching for creativity towards sustainable and replicable pedagogical practice. They explored the pedagogical significance of recent shifts in scholarly attention away from first generation and toward second generation understandings of creativity. First generation or ‘big C’ creativity locates the creative enterprise as a complex set of behaviors and ideas exhibited by an individual, while second generation or ‘little C’ creativity locates the creative enterprise in the processes and products of collaborative and purposeful activity. Second generation creativity is gaining importance for a number of reasons: its acknowledged significance as a driver in the new or digital economy; recent clarification of the notion of ‘creative capital’; the stated commitment of a growing number of universities to ‘more creativity’ as part of their declared vision for their staff and students; and recognition that the creative arts do not have a monopoly on creative capability. Thus, the following set of principles for sustaining a replicable pedagogical environment for creative learning outcomes has been concluded (McWilliam & Dawson, 2008):

1. **Connectivity with Diversity**: An environment in which it is important for students to be “plugged into” and mindful of a “local neighborhood” and a larger world of potential team members with
similar interests or passions—one that allows members to pursue their passions and to contribute to fast-moving flows of information on behalf of others and themselves.

2. **Co-Invention/Co-Creation with Separation**: An environment in which the nature, purpose and rules of self-management are understood and internalized, so that members can be both separate from, and attentive to, those they work with and rely on for their “high flying” outcomes. The products of learning are authentic productions of the synergies that exist between the individual member and the team, not merely what is “required” by external others.

3. **Leading and Following**: An environment in which all team members share collective responsibility for timely and appropriate leadership, looking over the horizon for relevant information for sharing with others, while at the same time following the “steering” of those close by—i.e. exercising “three dimensional” attention about the local and global, the present and the future.

4. **“Enhancing” Constraints and Removal of Inhibitors**: An environment that minimizes command and control, while providing scaffold opportunities for members to conduct themselves in ways that optimize team (and thereby their own) performance—one in which there are “good constraints to action”.

5. **Explaining Less and Welcoming Error**: An environment in which “command and control” instruction is sparingly used and it is anticipated that all members will make mistakes—the aim is to learn from the instructive complications of error or attempt to disguise it.

Undoubtedly, encouraging and enabling the development of students’ creativity requires more than writing policies, although this is a starting point. To establish a new experiential paradigm centered on cultivating creativity requires nothing less than an institutional intervention (Livingston, 2010). The need for creativity has never been greater as the role of a higher education teacher becomes more complex in its demands and challenges, and notions of professionalism in higher education become far more extensive (Wisdom, 2006).

**PROBLEM-BASED LEARNING (PBL) AS A STRATEGY FOR CREATIVE PROBLEM SOLVING**

Pedagogical strategies such as project-based and team assignments have been successfully used in classroom settings to foster a greater depth of learning and creativity (Newman, 2005). For example, the effectiveness of problem-based learning (PBL) was examined during recent years, showing that some skills like teamwork, problem solving, leadership, and life-long learning, etc. can be developed (Zhou, Kolmos, & Nielsen, 2012). PBL is supported in many ways by theories in the learning sciences, ranging from constructivism and cognition to creative problem solving. Those theories have also been involved in discussions on creativity development in PBL (Zhou, 2012). For example, Tan (2009) provided a comprehensive understanding of why and how creativity can be fostered by PBL from different perspectives, such as cognitive, sociocultural, psychological, and socio-psychological. These points drive the structure of the following sections by linking 1) problem solving, 2) group learning, 3) interdisciplinary learning, 4) project management, and 5) facilitation with PBL.

Problem solving is viewed as a component of PBL and some universities put more emphasis on it than others. For example, the seven steps to problem solving developed by the University of Maastricht are often used in cognitive science (De Graff & Kolmos, 2007). In the recent work related to PBL, this
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issue has been discussed mainly focusing on the role of open, ill-defined or real-life problems or projects (Tan, 2009) and a collaborative problem solving context (Zhou & Kolmos, 2013) in creativity. As mentioned above, in problem solving for a real-life context, the learning process is seen as a creative, dynamic and iterative process. This process involves identification of the problem and the problem constraints; identification and clarification of multiple, and possibly conflicting, perspectives of the problem; generation of possible solutions; assessment of the viability of alternative solutions through argument construction and articulation of personal beliefs and assumptions; monitoring of the metacognitive processes involved in the problem solving activity; testing and recommendation of a solution; and adoption of a solution (Lohman & Finkelstein, 2000). However, a critical aspect of problem solving is that people hold multiple, and sometimes conflicting, perspectives on the nature of the problem, the procedures for solving it, and the appropriate solutions.

Group learning can be a valuable tool for promoting creative problem solving skills. Since group interaction can provide a basis for exchanges of information among group members, effective groups should have individuals with diverse knowledge, skills, or new perspectives and should be motivated toward a full exchange of ideas (Zhou, 2010). Task-related diversity is therefore needed in groups for different ideas to generate. Individuals with different backgrounds may have different value systems, ways of thinking, and attitudes towards collaboration, etc., which may be shaped by different social or cultural environments and may influence the group process of ideas generation (Zhou, Kolmos, Du, & Nielsen, 2011). Gregory et al. (Hmelo-Silver, 2004) proposed that subjects such as the use of group activity to obtain many views rapidly, the use of network and interaction for describing problems, and the use of groups to generate ideas should be employed in teaching problem solving courses. This can foster higher order thinking skills such as analytical reasoning, synthesis of multiple information that streams into a whole that is indeed greater than the sum of its parts, and evaluation (Zhou, Kolmos, & Nielsen, 2012). Group work can therefore facilitate not only the acquisition of knowledge but also several other desirable attributes, such as communication skills, teamwork, problem solving, independent responsibility for learning, sharing information and respect for others (Zhou & Kolmos, 2013).

Interdisciplinary learning is one of the models of PBL, according to studies such as Savin-Baden (Smith, 2005) and De Graaff and Kolmos (2007). Interdisciplinary learning may bridge the gap between know-how and know-that, and between different forms of disciplinary knowledge. According to studies on communities of practice (Wenger, 1998), interdisciplinary projects require the contribution of multiple disciplines. Participating in these kinds of project exposes practitioners to others in the context of specific tasks that go beyond the purview of any view of any practice. People confront problems that are outside the realm of their competence but that force them to negotiate their own competences with the competences of others. Moreover, competence and experience are in different relationships at the core and at the boundaries of practices, at the encounters between generations, and in relationships of power among participants. The innovation potential of a system lies in its combination of strong practices and active boundary processes—people who can engage across boundaries, but have enough depth in their own practice that they can recognize when something is really significantly new. Accordingly, simultaneous participation in communities of practice and project teams creates learning loops that combine application with capability development (Wenger, 1998). Recent creativity study (Craft, 1995) has suggested that much new thinking at the level of “high creativity” does involve the merging of ideas from two or more disciplines.

Project management is essential to support learning activities in PBL. Amabile (1996) suggested good project management is one of the qualities in a work environment that serve to promote creativ-
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From a socio-psychological approach. Meanwhile, other related qualities have been proposed such as freedom in deciding what to do or how to accomplish the task; the sense of control over one’s own work and ideas; management enthusiasm for new ideas and their ability to create an atmosphere free of threatening evaluation; sufficient resources and time pressure, and so on. The ability of a manager will be tested to the utmost when complex technical changes demand a high level of corporate activity. A premium is placed upon fixing clear objectives, and setting up high response decision-making, communication and control systems to enable a wide range of resources and disparate talents to be harnessed to the full (Zhou, Kolmos, Du, & Nielsen, 2011). The social theory of learning indicates the project group works as a community and needs multiple forms of leadership: thought leaders, networks, people who document the practice, and pioneers, etc. These forms of leadership may be concentrated in one or two members of the group or widely distributed, and will potentially change over time (Wenger, 1998). Although most studies on project management are concerned with a business context, especially when creativity is discussed (Paulus, 1999), it has been considered a way for students to have a social approach to learning in PBL by researchers such as De Graff and Kolmos (2007), Zhou et al. (2013), and Smith (2005), for students are encouraged to involve themselves in it.

Facilitation of supervisors is critical to making PBL function well. As many studies have emphasized, teachers should hold on to the philosophy of student-directed education when solving problems with group work in PBL (Zhou, 2012). According to Hmelo-Silver (2004), the PBL facilitator plays an important role in modeling the problem solving and self-directed learning skills needed for self-assessing one’s reasoning and understanding, and supports the learning and collaboration processes which make students better able to construct flexible knowledge. Facilitation is a subtle skill. It involves knowing when an appropriate question should be asked, when the students are going off track, and when the PBL process is stalled. For example, Dolmans (2001) mentioned that if group work has a negative outcome because some group members are contributing less to the group’s activities and not doing the necessary work, it is suggested that supervisors help the group to perform better as a whole and to develop group spirit by evaluating on a regular basis, making the tutorial group meetings clear, and during mid-term evaluations reiterating their expectations about attendance, active participation, etc. Thus group learning is no guarantee of successful learning, but the stimulation of interactions between students is a prerequisite, which is the same with group creativity development.

Besides the above five aspects, it has been much argued in the literature that student-centered learning is the core philosophy of PBL (Zhou et al., 2012). Cognitive studies show that students will be more creative when internally motivated, when they feel some ownership of or control over the learning process, and when they look beyond one correct answer (Newman, 2005). However, some challenges have been discussed accordingly in the shift from teacher-led to student-centered education (Dolmans, 2001). PBL places high demands on the problems used and on the skills of the supervisor in order to ensure that cooperative learning in group work positively influences student learning or leads to better learning than individual learning (Zhou, 2012).

INFORMATION AND COMMUNICATION TECHNOLOGY (ICT) AS A TOOL FOR A CREATIVE LEARNING ENVIRONMENT

In thinking about how we might teach for creativity with digital technologies, a key factor is the development of learning environments which provide opportunities and promote an ethos that supports creativity.
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Contexts that are conducive to creativity reflect the qualities of exploration, play, taking risks, reflection, flexibility, focus, commitment and sensitivity to valuing the endeavors of individuals and communities. In all of this, motivation is a key factor for stimulating creative performance and the notion of self-directed learning is crucial to the development of the independent thinker (Ferrari, Cachia, & Punie, 2009). Information and communication technology (ICT) resources can support the creation and development of ideas if they reflect an approach to open-ended exploration in design and use (Loveless, 2007).

ICT can be seen as a set of tools which can be chosen as and when they are appropriate in the creative process. It can be argued that the characteristics of ICT can also make a distinctive contribution to those processes, proving new tools, media and environments for learning to be creative and to learn through being creative (Loveless, 2007). The uses of ICT to support creativity by learning design have been described, reviewed and theorized in a range of published work in recent years (Loveless, Burton, & Turvey, 2006). As emphasized by Craft (2006), ICT plays an increasing role, both offering the potential for creativity and demanding it in the ways that we represent and engage with the physical and social world, demanding simultaneous operation with multiple and co-existent sets of possibilities by aligning virtual and physical space in the co-occupation of time. In particular, the use-centered approach to learning design by ICT can be viewed as a potential strategy to promote learners’ creative thinking skills and improve learning abilities (Purushothaman, 2013). As explored by the domestication theory, the arrival of ICT in homes has brought with it the mobilization of material resources, skills, cultural values and social competences and capabilities. The recent rise of social media is also having an influential impact on organization innovation. These applications have shifted the way users seek information and create and connect knowledge (Loveless, 2007). Therefore current pedagogical discourses, such as the usages of ICT, attempt to view learners as the center of the teaching and learning processes, with an active role in the production of knowledge and meaning, democratically bringing their expertise, experiences and ideas into the learning environment. This should reflect a shift in pedagogy, moving towards an inclusive approach, where the environment is permissive and safe and where learners are in control of their learning process (Ferrari, Cachia, & Punie, 2009).

Learning in a creative way can certainly be a form of meaning making by employing innovative teaching strategies, while making good use of ICT is one of those strategies. Wheeler, Waite and Bromfield (2002) proposed a model of the creative use of ICT in learning that includes dimensions of problem solving, creative cognition and social interaction. The model shows that the three dimensions are independent but interactive, and in some cases it may be difficult to separate and distinguish between them. This means creativity development would therefore need to incorporate social interaction within the community of activity. Furthermore, according to Loveless, Burton and Turvey (2006), the framework for creativity and ICT attempted to describe the interaction between three elements of creative practice with ICT: creative processes (for example, using the imagination, fashioning, pursuing purpose and evaluating originality and value); the features of ICT (for example, provisionality, interactivity, capacity, range, speed, automatic functions and multimodality); and ICT capability as an expression of elements of higher order thinking—finding things out, developing ideas and making things happen, exchanging and sharing information and reviewing, modifying and evaluating work as it progresses, through breadth of study. Thus it is important to note that it is not the access to digital resources which delivers creativity, but the opportunities such access affords for interaction, participation and the active demonstration of imagination, production, purpose, originality and value (Loveless, 2007).

However, interaction with technology is primarily based on how the users understand the capacity of the technology. Teaching for creativity, or enhancing learners’ creative skills, requires the practitio-
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ners to be creative themselves and to provide learners with an ethos and a culture that values creativity. The creative and effective teacher relies on a series of resources that include ICT, but also realia (i.e., real objects), manipulatives (i.e., resources that can be manipulated), and innovative resources (Ferrari, Cachia, & Punie, 2009). Therefore teachers’ proficiency in using technology is a key issue. Teachers who are not conversant with the technologies they use in their teaching may not feel comfortable with showing their lack of expertise in front of their students. This means that if the teachers want students to be creative with technology, they have first and foremost to teach them how to use it. The skill of teaching to foster creativity has to be a combination of structured and unstructured activities to enable unconscious as well as conscious thought and where intuitive reasoning is as valued as rational calculation. There is a fine balance between freedom and control (Loveless, Burton, & Turvey, 2006). Teachers are expected to try to integrate new ways of teaching using their students’ technology, through which to facilitate the knowledge conversation when the combination of structured and unstructured activities is formed through participation in collaborative contexts. Hence basic technology skills are prerequisites for creative learning (Ferrari, Cachia, & Punie, 2009); the role of the teacher within and outside virtual spaces is important in teaching students how to be creative in their learning environments.

Like any other habits, creative habits of mind do not appear overnight. To see how creative mentalities might be developed, the educators have to attend to the culture that operates from primary school classrooms to higher education, and to a process of cultivation that is slower than ‘teaching’ or ‘training’, but possibly more effective in the longer run (Claxton, Edwards, & Scale-Constantinou, 2009). Particularly in terms of the shift toward ICT-based creative learning design in developing contexts, challenges exist both in technology and in the social sciences. For example, reducing the digital divide requires improvements across all dimensions of ICT (dubbed the 4C framework): computing, connectivity, content, and human capacity (Wang & Zhou, 2013).

- **Computing:** PCs are prohibitively expensive for most people, and shared access (e.g., community centers or cybercafés) becomes inevitable. PCs today are very difficult to use, and even “experts” spend a lot of time maintaining their machines, worrying about updates, security, compatibility of hardware, etc. As a complementary technology, non-PC devices are an important option—e.g., mobile phones.
- **Connectivity:** While mobile technology is improving worldwide, it remains expensive, limited in rural areas, and poor at proving data connectivity.
- **Content:** Meaningful content is lacking in many languages, and most content is not locally relevant. Today’s systems tend to make people passive consumers of information instead of enabling generation of local information. In addition, rich content demands multimedia (useful to overcome literacy issues), which, in turn, requires broadband connectivity.
- **Human Capacity:** Users need to be aware, literate, and innovative to harness the power of ICT. They also should be empowered to use ICT, both by society and by the state.

In the long run, therefore, ICT must provide value and be sustainable from both a user and a provider perspective. Designers and developers of ICT could consider innovative ways to work with and develop understandings of the nature of digital technologies as a medium in the creative process (Tongia, Subrahmanian, & Arunachalam, 2005). A creativity framework should underpin planning, practice, and evaluation. The framework should recognize the interaction between individuals and communities,
processes, domains and fields, and the characteristics of imagination, fashioning, pursuing purpose, originality and value judgments (Loveless, 2007).

CONCLUSION

Higher education is a place where the teachers try to understand the world in all its rich complexity and glorious detail, but it is also a place where teachers prepare students for a lifetime of working with their own complex issues and problems (Jackson, 2006). This underpins the significant value of fostering creative problem solvers, as creativity may help the young students to shape new knowledge, find new solutions to problems, and engage in collaborative activities when the emergent challenges are managed. While creative problem solving skills can be instilled in students through a creativity training approach, this means providing creativity training with a series of thinking techniques to students explicitly, as well as exercises or opportunities to employ them; another approach is to build an atmosphere that stimulates creative thinking by improving motivation, ownership, freedom, and psychological safety, etc., which has laid the basis of innovative strategies such as PBL or using ICT. It should be emphasized that confidence that ‘everyone can be creative’ should be encouraged and the sense of ‘being a creative problem solver’ should be improved. This also means ‘creativity’ should be a part of a student’s professional identity. Using the definition offered by Wenger (1998), identity could be a way of talking about how learning changes who the learners are and creates personal components within learning, placing it at the center as the primary focus, where the figure would still make sense. It is concerned with what the students become through their interaction with significant others, their experience of new learning opportunities, and their engagement with dominant social representations of their culture. Therefore the experience of identity is in practice a way of being in the world and a representation of the self-belief and self-confidence which learners bring to new learning challenges and contexts. In this sense, a good way to help students to learn about creativity is for a teacher to reveal his/her own creativity and show students what it means to them in their own practice (Jackson & Sinclair, 2006). The best strategy is therefore to create university cultures where the best students are free to express their creativity and set their own agendas, not being entrained in hierarchies of deference to their seniors, no matter how distinguished these might be.

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### KEY TERMS AND DEFINITIONS

**Complex System:** A complex system means a system whose perceived complicated behaviors can be attributed to one or more of the following characteristics: large number of elements, large number of relationships among elements, non-linear and discontinuous relationship, and uncertain characteristics of elements.

**Complexity Theory:** It refers to a cluster of ways of thinking that have developed over the past decades from branches of ‘new science’ concerned with the behavior of nature systems, such as Chaos Theory, Dissipative Structure Theory, and Quantum Physics. It offers a way of thinking about human system.

**Creativity:** Etymologically speaking, the term “creativity” means to generate new and useful ideas. The field of creativity was practically started from psychological studies. Today the field has seen an explosion of interest: creativity has been discussed much by the theories such as psychology, social psychology, cultural psychology, social culture and even philosophy.

**Information and Communication Technology (ICT):** ICT can be seen as a set of information technological tools that can be chosen as supporting educational environment. The technological resources can support the creation and development of ideas by stimulating the learners to engage into deeper learning process and activities.

**Problem Creative Solving (CPS):** It is most often discussed as a thinking skills model. CPS is a ‘toolkit’ approach to creative thinking which often frustrates those people who believe that there is no way that you can ‘teach’ creativity but that is an inherent quality of a person. A popular creative thinking exercise is to follow stages including 1) preparation, 2) question formulation, clarification and reformulation, 3) purge, idea generation and incubation, and 4) idea clustering.

**Problem:** It can be defined as a wondering which takes the concrete from of a question; it can be characterized as discrepancy between hypothetical normal condition and a fact with diverge from it; it is a form of appearance for contrasts, conflicts and contradictions.

**Problem-Based Learning (PBL):** As an innovative educational model, Problem-Based Learning (PBL) has been widely used in diverse disciplines and cultures throughout the world. In PBL, students’ learning centres on complex problems that do not have a single answer or solving real-life projects. Students work in collaborative groups to identify what they need to learn in order to solve the problems. The teacher acts to facilitate the learning process rather than to provide knowledge. So “student-centred learning” is the core philosophy of PBL.
Section 2

Creativity Across Disciplines
Chapter 2
Thinking Inside the Box:
Educating Leaders to Manage Constraints

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ABSTRACT

Despite the importance of constraints in creative efforts, little research examines the role of constraints in the creative process, how leaders manage these constraints, and implications for educating leaders of creative efforts. The present chapter synthesizes the literature on constraints and leadership of creative efforts to provide an initial framework of constraints and creativity. Furthermore, this chapter proposes an initial model of constraint management portraying the cognitive and practical processes leaders engage in when managing constraints. The complex and dynamic nature of constraints, as highlighted by the model, emphasizes the need for educational efforts specifically addressing constraint management in creative endeavors. Therefore, this chapter provides practical suggestions for educating future leaders in constraint management.

CONSTRAINT MANAGEMENT IN CREATIVITY EDUCATION

The Labs management made an effort to isolate its scientists from the gritty day-to-day political concerns of the business. But the managers themselves had to keep track of how the technology and politics and finances of their endeavor meshed together. Indeed, they could never forget it. As long as the business remained robust – and it was the primary job of people like Mervin Kelly to keep the business robust – so did the Labs. - John Gertner, The Idea Factory

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Thinking inside the Box

Today’s highly competitive and rapidly changing market necessitates that organizations innovate in order to achieve success (Shalley & Gilson, 2004). Indeed, a number of studies demonstrate the criticality of innovation to organizational performance (e.g., Eisenhardt & Tabrizi, 1995; Geroski, Machin, & Van Reenen, 1993; Jiménez-Jiménez & Sanz-Valle, 2011; Roberts, 1999). Naturally, innovation, or the implementation of creative ideas (Mumford & Gustafson, 1988), depends upon creativity, or the generation of creative ideas. Thus, it is not surprising that leading organizations place a high value on personnel exhibiting creative problem solving skills (Mumford, Scott, Gaddis, & Strange, 2002).

Although organizations place a high value on creativity and innovation, educational institutions have traditionally underemphasized the development of creative thinking in students (Sternberg, 2006). Strides have been made in recent decades, however, to identify curriculums and learning environments that support the development of student creativity (e.g., Cole, Sugioaka, & Yamagata-Lynche, 1999; McWilliam & Dawson, 2008). In addition, a number of instructional approaches have been identified which may be particularly promising for informing the transformation of traditional educational strategies towards alternative approaches that emphasize the development of creative potential (e.g., Scott, Lonergan, & Mumford, 2004). Nevertheless, course assignments and activities in higher education, on the whole, continue to be characterized by traditional approaches to instruction which overemphasize acquisition of declarative knowledge (Fasko, 2001). For example, exposing students to group-based projects that involve the development, refinement, and implementation of a product or idea in response to a novel, complex, ill-defined problem remains the exception in classrooms, rather than the norm. As a result, students enter the workforce unprepared to solve complex problems, tolerate ambiguity, and lead others in creative projects.

One approach to developing creative thinking that has received little attention is the management of constraints. In popular culture, “thinking outside the box” has become synonymous with creativity. Indeed, the advice has been repeated often enough, and convincingly enough, that the catchphrase now represents a fundamental and pervasive misconception about creative work—that constraints are bad for creativity. This idea ignores the fact that creative work is, by nature, complex, demanding, and highly constrained. Leaders of creative efforts play a key role in facilitating project success by managing this complexity and providing domain-relevant expertise, resources, critical feedback, and creative problem solving skills (Vessey, Barrett, Mumford, Johnson, & Litwiller, 2014). The opening quote demonstrates this idea well. At the Bell Labs, leaders such as Mervin Kelly had to manage the creative process, taking into account constraints such as available technology and resources, among others. Thus, identifying strategies for educating students, the future leaders of creative efforts, to manage constraints inherent in creative projects may be of critical importance. The following pages provide a summary of creativity training efforts, present a brief taxonomy of potential constraints across multiple levels, propose a model of constraint management, and discuss implications of training constraint management in education settings.

CREATIVE PROBLEM SOLVING

Creative problem solving refers to the production of high-quality, original, and elegant solutions (Besemer & O’Quinn, 1999; Christaans, 2002) to complex, novel, and ill-defined problems (Mumford & Gustafson, 1988, 2007). Developing effective solutions to problems requiring creative thought involves a series of interactive processes. Researchers have proposed several process models (e.g., Amabile, 1996; Mumford, Mobley, Uhlman, Reiter-Palmon, & Doares, 1991; Wallas, 1926) to explain how individuals
work through creative problems. Wallas (1926) suggested four stages, including preparation, incubation, illumination, and verification. Similarly, Amabile’s (1996) model proposes four stages including problem or task identification, preparation, generation, and validation. Mumford et al.’s (1991) model decomposes the creative process further by suggesting eight stages, including problem identification, information gathering, concept selection, conceptual combination, idea generation, idea evaluation, implementation planning, and monitoring. Although each model possesses unique features, the general sentiment remains the same – creative problem solving requires a series of processes focused on generating and evaluating potential solutions to complex problems.

These models imply the inherently constrained nature of creative problem solving. Each model begins with a variation of problem definition, requiring problem solvers to work within a limited problem space. Furthermore, these models include an evaluative component, suggesting that solutions must be assessed to a standard to determine if the problem has, in fact, been solved. Together, these processes suggest that unconstrained idea generation fails to produce viable solutions. Instead, one must identify the problem at hand, propose solutions, and evaluate solutions to the current problem. This constrains the process to allow for creative thinking within a limited problem space.

Leaders of creative efforts maintain the difficult task of orchestrating a team to effectively execute these processes (Mumford, Scott, Gaddis, & Strange, 2002). In order to direct these processes, however, leaders must be skilled in their application themselves. Thus, successful leaders of creative efforts possess more than managerial skill. Leaders must also possess the ability to identify relevant problems, gather pertinent information, generate solutions, evaluate solutions to appropriate standards, and ultimately, implement these solutions. This necessitates that leaders of creative efforts possess a combination of complex problem solving, solution construction, and social judgment skills (Mumford, Zaccarro, Connelly, & Marks, 2000). Thus, educational interventions targeted towards leaders of creative efforts should focus on creative problem skills in addition to more traditional managerial skills.

**CREATIVE PROBLEM-SOLVING TRAINING**

Given the importance of creativity and, by extension, leadership of creative efforts, many organizations and educational institutions have developed interventions to improve creative performance (Scott, Lertiz, & Mumford, 2004) in fields such as marketing (Rickards & Freedman, 1979), educational administration (Burstiner, 1973), medicine (Estrada, Isen, & Young, 1994), engineering (Basudar, Graen, & Scandura, 1986), and fashion design (Karpova, Marcketti, & Barker, 2011). These interventions are employed in a wide variety of age groups ranging from kindergarten students (Meador, 1994) to college students (Daniels, Heath, & Enns, 1985). Furthermore, creativity trainings employ a series of approaches. These approaches include a focus on cognitive processes, personality characteristics, motivation, and social interactions (Scott, Leritz, & Mumford, 2004).

For example, Pearson and Butler (2002) trained Research and Development (R&D) employees in creative problem-solving processes using a problem-based approach. The R&D employees worked through these problems by engaging in problem identification, solution, evaluation, and planning processes. Results suggested a positive relationship between creative problem-solving training, employee’s idea fluency and flexibility, and R&D performance as measured by the number of co-authored service projects. In comparison, Edwards Gerrard, Poteat, and Ironsmith (1996) used a motivational training by showing children a video (Hennessey & Zbikowski, 1993) focused on intrinsic motives. Results sug-
gested a marginally significant relationship between the training and creative performance as judged by teachers. As an additional example, Clapham (1997) conducted a 30-minute training where participants generated ideas, engaged in relaxation exercises, discussed the importance of creativity, and reviewed idea generation techniques. These three trainings provide only a few examples of the varied methods employed in training efforts. Thus, as described by Scott, Leritz, and Mumford (2004), creativity trainings certainly range in their focus.

Despite this range, a majority of creativity trainings aim to increase trainees’ creative problem solving or divergent thinking skills. Creative problem-solving skills refer to the aforementioned processes such as problem identification, idea generation, and idea evaluation (e.g., Amabile, 1996; Mumford et al., 1991; Wallas, 1926). Pearson and Butler’s (2002) previously discussed training effectively demonstrates this approach. On the other hand, divergent thinking refers to the production of multiple potential solutions (e.g., Christensen, Guilford, & Wilson, 1957; Guilford, 1950). Creative problem solving is typically assessed at the process level, whereas divergent thinking is traditionally measured in terms of the number of responses (fluency), number of categories into which these ideas fall (flexibility), and originality or novelty. For instance, Baer (1996) conducted a divergent-thinking focused training with seventh-grade students. Students completed a series of exercises including rhyming, alliteration, metaphors, and images intended to improve flexibility, originality, and elaborative thinking. Divergent-thinking trainings may prove effective at increasing the number of solutions generated but they fail to address convergent processes such as critical and evaluative thinking that are crucial to “real-world” creative efforts (Fasko, 2001).

In a meta-analytic review, Scott, Leritz, and Mumford (2004) identified four important characteristics of successful creativity trainings. First, training interventions should focus on cognitive activities involved in creative problem solving. Second, interventions should be lengthy and involve challenging activities targeting discrete cognitive skills. Third, interventions should incorporate case-based illustrations of real-world creative efforts. Lastly, domain-specific practice opportunities should follow instruction and illustrations. These findings suggest that creative problem-solving development efforts should focus on more than just divergent thinking or idea generation. Other processes and activities relevant to the creative process should be included in these training efforts. Furthermore, simply improving generative processes without attention to the domain or real-world implications fails to adequately prepare learners for the myriad of challenging processes and activities they may encounter in a real-world setting. Thus, in order to improve creative problem solving, it is important to identify additional, untapped activities and processes that may be critical in successfully executing creative efforts. One such area receiving growing attention in the research literature is constraint management.

Initial examinations of constraint management training suggest promising results. In one study (Peterson, Barrett, Hester, Robledo, Hougen, Day, & Mumford, 2013), researchers provided participants with definitions of several types of constraints. Participants also received descriptions of how each constraint may influence creative problem solving. Participants received a varying amount of constraint descriptions, with some participants receiving none and some receiving up to four. Additionally, they received strategies for how to effectively manage these constraints. Next, participants were asked to solve a social innovation problem and apply the constraint management strategies presented in the training. Solutions were content coded for quality, originality and elegance, three measures of creative performance stemming from Bessemer and O’Quinn’s (1999) conceptualization. In general, training participants on constraints resulted in higher quality, originality, and elegance of solutions compared to the control (no training) group. More specifically, training participants on constraints proved particularly beneficial for
more talented individuals. Results from this study provide initial evidence pointing to the efficacy of constraint management interventions in improving creative problem solving.

Despite the influential role of constraints in creative efforts and promising initial results of constraint management training, the research in this area remains incipient. Thus, this chapter aims to provide an initial framework for the management of constraints in creative efforts. Drawing from both the available literature on constraints and more broadly, leading creative efforts, the present chapter describes the nature of constraints in creative problem solving, provides a cognitive and practical constraint management model, and suggests implications for educating leaders of creative endeavors.

CONTRACEPTION

Traditionally, constraints were thought to inhibit creative problem solving (Osborn, 1953). However, findings from recent empirical and case study research point to a more nuanced conclusion. That is, constraints can serve both inhibitive and facilitative roles in the creative problem solving process, depending upon a number of situational characteristics. Specifically, at least five characteristics of constraints appear important to understanding the complex operations of constraints on creative projects, including: 1) number, 2) extensiveness of impact, 3) flexibility, 4) dynamism, and 5) interactions.

First, the number of constraints may be expected to influence creative problem solving. On the one hand, constraints provide critical information that must be taken into account in order for a project to be successful (e.g. timeline, resources, customer needs, production limitations, etc.). On the other hand, no individual, or team of individuals, may be expected to have the capacity to consider all potential constraints that may be operating on a project at any given time. As a result, attempting to consider too many constraints simultaneously is likely to be more disruptive to creative problem solving than informative. However, it is noteworthy that individual differences may impact a person’s capacity, and willingness, to analyze multiple constraints. Indeed, Medeiros, Partlow, and Mumford (2014), in a low-fidelity simulation study of undergraduates engaged in a creative advertising task, found this to be the case. Specifically, participants reporting higher levels of cognitive motivation, as measured by Need for Cognition (Cacioppo & Petty, 1982), demonstrated greater capability in managing multiple constraints, resulting in the production of more creative solutions. Thus, although the number of constraints one is asked to analyze appears important to managing constraints, leaders of creative efforts must also be capable and willing to work with the constraints imposed upon the project, often times multiple constraints operating in a simultaneous fashion. Therefore, understanding when to shift attention towards, and away from, specific constraints may be critical to the leadership of creative efforts.

Second, the extensiveness with which individual constraints are imposed upon creative projects appears to impact creative problem solving. For example, in a survey study of 264 departments across two multinational corporations, Nohria and Gulati (1996) found evidence of a curvilinear relationship between organizational slack and innovation. Specifically, they found that a moderate level of slack, or organizational resources devoted to innovative projects, was optimal for supporting innovation. Alternatively, too little or too much slack, they interpreted, appeared to inhibit project innovation, by producing too much strain on project resources in the former case and by allowing too many resources for project exploration in the latter case. Therefore, teaching leaders of creative efforts to identify nonlinear influences of constraints—that is, extensiveness of impact—may help leaders to employ strategies for operating on constraints.
Third, constraints appear to vary with regard to their flexibility, and acting on constraints that are more susceptible to modification may be critical to the leadership of creative efforts (Medeiros, Partlow, & Mumford, 2014). Indeed, a field study of product development teams at Coloplast (Onarheim, 2012) suggests that leaders of creative efforts spend a great deal of time discussing more flexible constraints but very little time on less flexible constraints. Further, in a low-fidelity simulation study, Peterson, Barrett, Hester, Robledo, Hougen, Day, and Mumford (2013) found that teaching undergraduates to manage flexible constraints, such as project resources or goals, resulted in the production of solutions to social innovation problems that were high in quality, originality, and elegance. However, talented participants also benefited from training in the management of less flexible constraints, such as product user skills and system parameters. Thus, although all constraints may be considered flexible to some extent, more resources and expertise are required to successfully act on less flexible constraints.

Fourth, the influence of constraints may shift throughout the lifecycle of a project—that is, constraints appear to operate dynamically. For example, in early stages, project deadlines are highly flexible. Once the final deadline has been set, however, project timelines become highly inflexible, requiring leaders to identify alternative constraints to act upon in the event of unexpected delays (e.g., requesting additional resources). Thus, training leaders of creative efforts to recognize how constraints may exert differential impacts across project stages may be important to team innovation.

Fifth, constraints do not operate in isolation. In other words, the demands imposed by constraints may be expected to interact with other constraints. For example, the complexity of a project interacts with other project characteristics, such as its scope, deadlines, and resources required for execution. More time and resources must be budgeted for projects that are more complex. In addition, the demands imposed by project constraints may be expected to interact with constraints from other sources, such as the field in which the creative team is operating. For instance, team member networks serve as a critical resource for projects by providing external sources of domain-relevant information (Hülsheger, Anderson, & Salgado, 2009). However, team member networks are fundamentally limited by the boundaries of field networks. Thus, team member networks, a constraint in its own right, is additionally constrained by the network of the field in which the team is operating, limiting access to external sources of information that may be relevant to creative projects. These points lead to an important conclusion. That is, constraints emerge from, and appear to interact across, multiple sources. Next, four sources of constraints on creative efforts are considered—the market, organization, field, and project.

**Market Constraints**

Creative work does not unfold in a vacuum. Rather, it occurs within a social context. Along these lines, the value of any new idea, service, process, or product is inherently tied to the benefits it brings to organizational stakeholders (Mumford & Gustafson, 1988). Market constraints, such as stakeholder expectations or demands, are forces that emerge within the organization’s external environment to constrain firm decisions, including decisions that influence the leadership of creative efforts. Four such market constraints and their influences on creative projects are described next, including: 1) competitors, 2) external customers, 3) regulatory agencies, and 4) turbulence.

First, competitors place constraints on creative projects. Firms that are unable to establish some advantage over competitors are unlikely to survive (Nadler & Tushman, 1999). Along these lines, speed to market, or the rate at which firms are capable of developing and marketing new products, appears critical (Carbonell & Rodríguez, 2006). However, speed to market, while important, may not always be a creative
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leader’s highest priority. Bayus (1997) proposed that firms must shape their strategy concerning new product development speed to fit with the environmental conditions (e.g., strength of competition). If a firm’s competitors are first to market with a high-performing product, rushing to add a mediocre product within a saturated market domain is ill advised. In this case, increasing development time to ultimately release a superior product may be a better strategy. If the firm’s competitors are first to market but their position is relatively weak, then speed to market might be prioritized over high product performance, assuming some alternative advantage (e.g., marketing) has been identified. Thus, knowledge of both competitor weaknesses and organizational capabilities appears critical. This knowledge might support the leadership of creative projects by informing the identification, definition, and selection of important problems to solve. Further, this knowledge might inform project objectives (e.g., emphasizing speed-to-market over product performance) that shape the timeline and resources allocated to creative teams.

External customers represent a key organizational stakeholder, and the expectations of external customers have the potential to influence a number of important leader activities related to creativity and innovation (Souitaris, 2001). For example, societal and global trends such as desire for more socially responsible business practices and products may serve as a catalyst for innovation. Along these lines, some industries may be more sensitive to shifts in consumer demands than others (Lieberman & Montgomery, 1988). Customer expectations may also drive the need for product line refinement (i.e., incremental innovation). Apple’s customers have come to expect the release of a new version of the iPhone every year. Thus, leaders of product refinement teams must plan several years in advance to ensure a consistent stream of incremental innovations are apparent. Although customer expectations may serve as input for leader decisions regarding project objectives, paying too much attention to customer expectations may undermine innovation by over-constraining projects during exploration stages (Berthon, Hult, & Pitt, 1999). Further, Veryzer (1998) proposed that the goals of R&D projects influence the extent to which leaders should seek customer input. For example, customer feedback appears to be a critical source of information when incremental innovations are desired. However, customer input may be much less valuable, and potentially detrimental, if sought for producing more radical innovations. In an analysis of Steve Jobs, Isaacson (2012) recalls Jobs’ reply to being asked if the team should review market research for customer input. His answer? No. In the words of Henry Ford he stated, “If I’d asked my customers what they wanted, they would have told me, ‘A faster horse!’” (Isaacson, 2012). The quote perfectly embodies this idea – if a company wants to incrementally improve their horse, then market research may be valuable. On the other hand, if an organization wishes to revolutionize transportation, market research may prove harmful. Thus, leaders of creative efforts must engage in a careful balancing act—knowing when to heed and when to ignore customer demands vis-à-vis the project mission. Also, leaders must plan for what they think customers might want in the future, they must also plan for how the new product might be positioned with some advantage in relation to competitors’ products.

Unlike external customer demands, external regulations tend to be highly fixed and exert a continuous influence on creative projects. External regulations include laws, rules, principles, or ethical guidelines established by regulatory bodies (e.g., government agencies) that specify industry practices, procedures, and outcomes that are considered acceptable versus unacceptable. Regulations provide minimum qualification criteria for evaluating the success of new products, especially in industries where consumer safety is a key concern. Given the potential consequences of failing to meet these standards (e.g., consumer injury or death, lawsuits), it is not surprising that monitoring product alignment with regulations and potential changes in regulations is a critical activity reported by R&D directors (Gupta & Wilemon, 1996). Indeed, changes in regulations, while viewed as disruptive by leaders of creative
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efforts, signal opportunities for innovation (e.g., revisions to product lines). Thus, leaders of creative efforts might benefit from developing a thorough understanding of industry standards and regulations and from monitoring changes in these regulations.

Finally, turbulence, or changes in environmental conditions surrounding the firm, may constrain the leadership of creative efforts. Turbulence comes in many forms, causing “shocks” to the organizational system. In this case, turbulence may include rapid shifts in customer demands, changes in external regulations, the introduction of some game-changing technology, the emergence of a new and strong competitor, or downturns in broader economic conditions. During recessions, for example, firms are more hesitant to invest in R&D (Yunlu & Murphy, 2012), directly constraining the resources available for leaders of creative efforts. Alternatively, technological turbulence appears positively related to firm innovation, when leaders are able to exploit changes in technology to the firm’s advantage (Calantone, Harmancioglu, & Droge, 2010). Further, in a study of 692 new product development (NPD) projects, Chen, Reilly, and Lynn (2005) found that market uncertainty moderated the influence of speed-to-market on NPD success. Specifically, they found that in conditions of high market uncertainty—such as novel, dynamic, fast-changing markets—speed-to-market was more important to NPD success. In other words, these observations suggest that different kinds of turbulence may exert different patterns of influence on creative projects, and leaders who are able to identify and adapt to these differential sources of turbulence may be particularly effective.

In sum, features of the organizational environment, such as firm competitors, customer demands, and industry regulations, appear to constrain the leadership of creative efforts. However, these features do not operate in isolation. Indeed, market constraints are dynamic forces that interact with one another and with organizational constraints to influence creative projects over time. Identifying market constraints vis-à-vis environmental analysis appears to be a critical function of leaders of creative efforts (Byrne, Mumford, Barrett, & Vessey, 2009). Next, another key source of constraints will be discussed in further detail—the organization.

Organizational Constraints

In addition to considering the environment, or market, in which the organization operates, considering features of the organization itself that constrain leaders of creative efforts may be of some value. That is, a range of constraints that are unique to each organization may have important influences on creative projects. Along these lines, four organizational constraints and their potential influence on creative projects are considered, including: 1) fundamentals, 2) production capabilities, 3) resources, and 4) internal customer demands.

Organizational fundamentals represent a form of highly fixed constraints that are closely tied to the mission and strategy of the firm (Teece, 2010). That is, fundamentals are assumptions about the core, value-producing functions of the organization, and these assumptions define the domains of problems that the organization is willing to invest resources to solve. Thus, organizational fundamentals significantly constrain leaders of creative efforts by narrowing the potential problem domains that R&D project teams might explore (Medeiros, Partlow, & Mumford, 2014). When project teams develop solutions (e.g., patents) that fall outside the bounds of organizational fundamentals, it is not uncommon for organizations to sell these solutions to other firms (Elkins & Keller, 2003). Project leaders that are attuned to organizational fundamentals are equipped to identify project solutions and implementation plans that are more likely to be supported and pursued by senior leaders.
Production capabilities represent another key organizational constraint (Onarheim, 2012). Due to the relatively fixed nature of these capabilities, it may be challenging for organizations to venture outside of their current product lines. Thus, organizational capabilities place constraints on the projects that creative teams might pursue. Nevertheless, organizations that lack the technological infrastructure required to produce and market new products might overcome these constraints by having critical alliances (e.g., suppliers, manufacturers, designers) in place to fill these gaps (Stuart, 2000; Teece, 1992). Leaders of creative efforts must be aware of organizational capabilities, but may also benefit from being open and willing to pursue new alliances that allow for innovation.

Organizational resources, closely associated with organizational size, have been recognized for some time as potential constraints on the leadership of creative efforts. After all, smaller organizations, or those with fewer resources, may be expected to allocate fewer resources to creative projects. This is, indeed, what scholars have found when examining the impact of organizational resources on innovation (Damanpour, 1992; Hunter, Bedell, & Mumford, 2007). For example, in a study of pharmaceutical firms, Cardinal (2001) found that organizational size was strongly related to objective measures of incremental ($r = .38$) and radical ($r = .57$) innovation. In early project stages, access to fewer organizational resources may be expected to limit the scope of what projects are considered feasible.

The demands and expectations of internal organizational customers, such as senior leaders, shareholders, and functional departments also place constraints on leaders of creative efforts. Due to increasing competition, firms are increasingly relying on R&D departments as profit centers, rather than as exploration centers (Gupta & Wilemon, 1996). Thus, in some firms, leaders who are not able to sell the immediate, return-on-investment benefits of a project may fail to get their projects funded. This places constraints on the range of ideas and projects that might be pursued by creative teams. These observations point to an important leader capability—given the expectations and demands of internal customers, leaders of creative efforts must be able to sell the value of their projects (Mumford, Mulhern, Watts, & Steele, in press).

In sum, organizational constraints tend to be highly fixed and influence creative projects most during early, exploratory stages of the project lifecycle. However, like market constraints, organizational constraints also appear to interact to constrain the leadership of creative efforts. When project leaders are embedded in organizations with few resources and a strong emphasis on immediate financial returns, for example, the range of creative projects that get funded may be expected to narrow considerably. With this potential for complex interactions of constraints emerging from the internal and external organizational environment in mind, field constraints, or constraints emerging from the profession, will be discussed next.

**Field Constraints**

In addition to market and organizational considerations, it is noteworthy that creative work occurs within the context of a “field”, or a professional network consisting of individuals with distinct, but highly related domains of technical expertise (Csikszentmihalyi, 1999; Feldman, 1999). Nevertheless, the field as a source of constraints has received little attention from creativity and innovation scholars. Creative people report stronger ties to their profession than to their organization—making the field an important source of information, norms, and resources for the guiding of creative efforts (Jaussi & Benson, 2012). In addition, it should be recognized that the creativity of any idea or product is a subjective judgment provided by the domain in which the product is produced (Ford, 1996). Bearing these observations in mind, Mumford, Bedell-Avers, and Hunter (2008) proposed that field constraints play a critical role in
shaping both the content and direction of creative projects. Thus, managing constraints imposed by the profession may be critical for the leadership of creative efforts.

This observation, however, leads to several important questions. If the management of field constraints is important to the leadership of creative efforts, what field constraints exert the greatest impact on creative projects? How amenable are field constraints to being acted upon by project leaders? And, recognizing the complexity with which projects evolve over time, at what project stages should leaders allocate their attention to various field constraints? As might be expected, the answers to these questions are not simple. Below, four types of constraints and their potential impact on the execution of creative work over time are described: 1) fundamentals/themes, 2) maturity, 3) networks, and 4) norms.

Field fundamentals refer to broad problems that frame the infrastructure of the profession that provide a foundation for the creative work being performed (Medeiros, Partlow, & Mumford, 2014). Creative work that fails to align with field fundamentals is likely to be considered illegitimate (Csikszentmihalyi, 1999). Similarly, field themes provide direction with regard to the goals, or areas of knowledge, considered valuable to the field (Mumford, 2003). Field fundamentals have been proposed as a driving force behind the themes pursued by a field (Hunter, Cassidy, & Ligon, 2012), and these themes, in turn, shape the projects pursued by creative teams. Thus, field fundamentals and themes significantly limit the range of problems available for exploration, impacting creative projects most during initial process stages. As might be expected, field fundamentals and themes are considered highly fixed, change slowly over several decades, and are upheld by “gatekeepers” (Csikszentmihalyi, 1990; Simonton, 2012)—senior members of the field that help determine what problems are worth pursuing. Leaders of creative efforts may choose to ignore field fundamentals and themes in later project stages to free up resources for acting on more flexible constraints. However, it should be recognized that leaders of creative efforts may also attempt to act on field fundamentals, albeit not without considerable expertise, cost, and risk. Indeed, educating leaders to identify field fundamentals and themes ripe for change in early project stages may provide unique opportunities for identifying radical innovations.

The maturity of the field may also be expected to constrain creative projects. For instance, more mature fields are associated with greater resources, technological capabilities, complexity, and domain diversity. As a field becomes more complex, the expertise required to engage in creative work becomes more specialized (Simonton, 2012). Specialization, by definition, narrows the range of problems considered feasible to explore. Thus, field complexity may constrain problem identification in the early stages of creative projects. In addition, more mature fields provide a greater range of technical resources for innovation. For example, firms specializing in nanotechnology, a highly promising but relatively young field, are limited in their resources for creative work due to the novelty of the field and the lack of available personnel with expertise in the area. Finally, in contrast to the notion that fields mature in a linear, incremental fashion, it appears that fields undergo occasional periods, or waves, of innovation (Wise, 1992). For example, the idea for the development of communications satellites surfaced decades before the technology required to produce or launch such satellites existed (Gertner, 2014). Leaders, therefore, may benefit from learning to assess the maturity and capabilities of the fields within which they operate.

Field networks refer to the web of professional relationships connecting members within a field to one another (Howell & Boies, 2004; Mumford et al., 2007). These networks primarily influence the flow of domain-relevant information, including number of ties, density, strength of ties, and centrality of individuals within networks (Perry-Smith & Shalley, 2003). Field networks, particularly those linking individuals within the firm to sources of expertise and information external to the firm, have also been proposed as particularly important to early stage innovation processes (Brentani & Reid, 2012).
For example, networks within fields are held to serve as sources not only of domain knowledge, but also as sources of critical feedback (Mumford, 2003). Thus, leaders of creative efforts in fields with well-developed, tight-knit networks may be at an advantage if they have access to these networks. Further, leaders of creative efforts may benefit from access to multiple field networks, as being overly entrenched in the network of a single field may inhibit creative thinking more than facilitate it (Sternberg, 2006).

Norms also vary by field. Field norms refer to the policies, processes, and procedures—both informal and formal—by which members of the field are expected to operate. For example, fields vary considerably with regard to the methods by which members communicate their findings (Kling & McKim, 2000). Fields may also vary with regard to the intensity of internal competition, placing constraints on the exchange of information among members. Although little research exists bearing on differences between field norms surrounding creative work, one might expect that leaders who are aware and sensitive to field norms might be better equipped to lead creative efforts.

In sum, field constraints play a central role in shaping creative efforts, particularly in the early stages of the project. Field constraints, although traditionally viewed as highly fixed, are not immune to change. Nevertheless, successfully acting upon field constraints requires considerable expertise, time, and other organizational resources. Finally, field constraints do not operate in isolation, but in a context of other constraints imposed by the profession and other sources. Next, a final, key source of constraints on creative efforts is described—the project.

Project Constraints

In addition to considering the market environment, field, and organization in which creative work occurs, it is important to consider how characteristics of the project itself might constrain creative efforts. Unlike the constraints outlined previously, project constraints impose direct, but relatively flexible, limitations on creative work. However, as discussed below, it is noteworthy that the impact and flexibility of project constraints may shift significantly throughout different stages of the project. The following four types of project constraints may be particularly influential on the management of creative efforts: 1) work characteristics, 2) team characteristics, 3) team networks, and 4) team climate.

Work characteristics refer to the mission, scope, resources, risk, complexity, and deadlines associated with creative projects (Paletz, 2012). Work characteristics may exert unique effects throughout different project stages. For example, the mission, or stated objectives of the project, is far more flexible in early project stages than in later stages. Indeed, leaders of creative efforts must devote a significant amount of time at the beginning of projects towards defining the mission. In turn, the mission shapes project scope, production goals, and deadlines (Mumford, Scott, Gaddis, & Strange, 2002), which ultimately become highly fixed in later project stages. Although these points will be somewhat obvious to leaders of creative efforts, it is nonetheless critical in any discussion of project constraints—deadlines should never be set without extensive collection of information concerning unknown project parameters. The number of unknown project parameters, that is, the number of ill-defined or novel problems that must be defined, explored, and solved in order for the project to succeed, contributes to the overall complexity, and thus risk, of the project. Resources, unlike scope and deadlines, may still be negotiated in later project stages, allowing for some flexibility. Thus, leader activities during early project stages, vis-a-vis mission definition and planning, have an important influence on the operation of constraints in later stages. Forecasting project risks in early project stages, and negotiating for additional resources in later project stages, may be two critical skills for leaders of creative efforts. In addition, through direct manipulation
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of work characteristics, leaders might increase or decrease pressure on subordinates to facilitate creative performance (Byron, Khazanchi, & Nazaria, 2010).

Team characteristics place unique constraints on creative projects, such as the number of team members, domains of expertise, and individual differences. These team characteristics place limitations on the range of problems that may be explored, and by extension the potential range and quality of solutions that may be developed and implemented. For example, as the number of team members increases, especially for complex, multi-functional projects, coordinating the timing and execution of task sequences among team members becomes increasingly complex. Indeed, Mumford, Bedell-Avers, and Hunter (2008) suggested that the ability of team members to adapt to, and communicate with, those of different functional backgrounds may be critical to the success of creative efforts supported by multifunctional teams. Thus, extensive leader expertise and planning skills are required to manage large project teams consisting of diverse backgrounds. Further, it has been suggested that leaders might navigate potential gaps in critical expertise by carefully selecting team members with not only diverse areas of expertise, but diverse preferences for various stages of the creative problem solving process (Basadur, 2004).

Team members, while embedded in networks specific to their field, are also embedded in their own personal network that places unique constraints on creative projects. Both internal networks, such as other team members and associates within the organization, and external networks, such as colleagues working outside the organization, play important roles by serving as sources of domain specific knowledge and expertise. Indeed, information exchange is held to support the idea generation and evaluation processes that are critical to innovation in teams (Drach-Zahayy & Somech, 2001). Although networks are traditionally viewed as resources for the project, networks may also be viewed as constraints, as networks serve as boundaries of information exchange. Thus, knowledge exchange may be particularly constrained for teams with tightly concentrated networks in a single, or less mature, field. Further, team networks have the potential to constrain creative projects most during the implementation planning stage (Hunter, Cassidy, & Ligon, 2012)—when collaboration across organizational departments or functions becomes critical. Training leaders of creative efforts to build relationships within and between functional departments (e.g., marketing, production, finance) and develop external relationships may help to mitigate the limitations of team networks.

Project climate refers to the shared perceptions of the project team members concerning features of the creative work environment. In a meta-analysis examining the relationships between 14 climate dimensions and creativity, Hunter, Bedell, and Mumford (2007) found that work climates characterized by positive interpersonal exchange, intellectual stimulation, and challenge produced the most sizable, highly positive effects on creative performance. Put differently, emotional conflict, poor communication, and an inappropriate level of project complexity (either too high or too low) can all inhibit team performance by restricting the flow of information among team members. Restricted information flow may be expected to have a debilitating effect on team performance across all project stages (Mumford, Medeiros, & Partlow, 2012). Poor climate characteristics divert team member cognitive resources away from the project, thereby limiting the team’s ability to identify and pursue important problems. These factors may also inhibit the team from effectively communicating with other teams.

In sum, the impact of constraints on creative problem solving is complex. Constraints operating on creative projects emerge from the market environment, the organization, the field, and the project, and these constraints vary with regard to a number of characteristics. As the total impact of constraints on any project increases, with regard to number, extensiveness, inflexibility, and dynamism, demands made upon leaders of creative efforts increase. Given the complexity imposed on creative projects by
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constraints, considerable cognitive resources, and complex problem solving skills, are likely required to effectively manage creative projects. Thus, training leaders of creative efforts to identify these constraints and the influence of their characteristics may help facilitate team innovation. Specifically, identifying how project constraints shift in flexibility throughout the project, and appropriately timing actions taken on these constraints, may be two critical skills to the leadership of creative efforts. Thus, the following section proposes a model for managing constraints.

CONSTRAINT MANAGEMENT MODEL

The dynamic nature of constraints demands a remarkable amount of cognitive effort from the leaders of creative endeavors. Leaders must not only identify critical constraints but must also understand how constraints uniquely and jointly impact the project at hand. This analysis, in turn, influences a leader’s planning efforts. Thus, leaders must balance a large amount of constantly evolving information while attempting to lay both short- and long-term project plans. The cognitive and practical difficulty of managing constraints in creative efforts should not be underestimated.

Despite the importance of constraint management to the success of creative endeavors, scant research exists in this area. The research available primarily focuses on the role of constraints on creative performance and remains in its infancy. Taken in tandem, however, with the leader cognition literature, one may begin to understand how leaders effectively manage constraints in creative efforts. Therefore, the following model (Figure 1) provides an initial set of propositions as to how leaders cognitively and practically manage constraints. The purpose of proposing such a model is to identify cognitive strategies and operations that leaders might target for development in order to more effectively manage the constraints inherent in creative efforts.

Scanning

Managing constraints begins with identifying information bearing on the project at hand. Leaders identify this information by scanning the environment both within and outside of the primary organization (Mumford, Schultz, & Van Doorn, 2001). Ultimately, scanning involves a search of the environment to identify information relevant to the project at hand – in this case, potential constraints. Constraints may arise from several areas including the particular project and the field within which one works. Thus, leaders must consider information both within their organization as well as information outside of their immediate work environment. Previous work establishes the importance of this process to creative efforts more broadly (e.g., Kobert, Uhlenbruck, & Sarason, 1996; Mumford, Eubanks, & Murphy, 2007). Given the dynamic nature of constraints, however, scanning becomes a particularly critical leader process when managing constraints.

While the model begins with scanning, it should not be assumed that scanning only occurs at the beginning of a project lifecycle. New information emerges regularly. Thus, it is likely the case that leaders ceaselessly scan the environment to identify new information and potential constraints in that environment. The next challenge becomes sifting through these constraints to identify the relevant and pertinent constraints for the project at hand.
Leaders must next comb through the information gathered in order to identify the pertinent constraints. Leaders likely evaluate the relevance of the constraints as they search the environment, but the importance of sorting relevant and irrelevant information should not be lost. Leaders simultaneously gather a large amount of information from a number of sources. The identification and subsequent implementation of irrelevant constraints may prove damaging by steering the team in the wrong direction or placing unnecessary restrictions on the team. Conversely, failure to identify relevant constraints may result in an inability to fulfill project demands. Indeed, Scott, Lertiz, and Mumford (2004) found constraint identification to play a significant role in creative problem solving. In their meta-analysis, constraint identification showed the largest positive effects on several measures of creativity including divergent thinking ($r = .16$), problem solving ($r = .39$), performance ($r = .28$), and attitudes/behaviors ($r = .29$). Constraint identification was only surpassed by critical thinking and convergent thinking. It becomes important then, to identify what information bears effect on the current project and what does not.
Appraising and Forecasting

Once leaders distinguish the relevant constraints from the irrelevant, they must appraise the constraints. Appraisal primarily focuses on flexibility and mission alignment. As previously noted, constraint flexibility refers to the probability that a leader is able to directly act on, or manipulate, a constraint, versus being required to work around the constraint. Fixed constraints set the boundaries for the project. For instance, if a project must be delivered within one year of its inception, then the leader and team must plan accordingly, making sure to meet this deadline. Inflexible constraints become the realities of the project within which the leader and team must work (Onarheim, 2012). Coloplast refers to these inflexible, or fixed, constraints as “corner flags” marking the project parameters. On the other hand, more flexible constraints may be manipulated and are not as limiting.

Alignment with the project mission refers to the extent to which the constraint compliments the mission at hand. The mission represents a relatively fixed constraint that the leader must continuously evaluate and to which gathered information, and constraints, must be evaluated. Continuous appraisal of constraints to the mission at hand, allows leaders to consider how each constraint, and set of constraints, support or inhibits this mission. This appraisal, in turn, influences subsequent constraint management processes.

In addition to appraising flexibility and mission alignment, leaders must also forecast the implications of acting on constraints. Previous research (e.g., Byrne, Shipman, & Mumford, 2010; Osburn & Mumford, 2006) has suggested the importance of forecasting for leading creative efforts. Given the dynamic nature of constraints, forecasting may play a particularly important role in constraint management. Forecasting includes both short- and long-term forecasts, examining the impact of constraints on early, middle, and late stage activities. As the criticality of constraints wanes or intensifies across project stages, it is integral that leaders consider how constraints differentially impact these stages in addition to the effort as a whole. Additionally, leaders must forecast how a set of constraints will influence one another as well as how a set of constraints will influence the project.

There exists a highly complex and interactive relationship between appraisal and forecasting. Once the leader determines the flexibility and mission alignment of the constraints, he or she must consider the implications across the creative effort lifecycle. These implications may, in turn, influence the leader’s appraisal. For example, if a project leader determines the physical material that the team must work with is highly flexible, this suggests that the team may use different types of materials when developing their new product. However, the leader may then forecast the implications of using certain types of materials during the production efforts and realize that certain materials are not feasible, practical, and are too costly. The leader, in turn, must reconsider and readdress their initial appraisal of the constraint as flexible.

Revising

Based on the appraisals and forecasts in previous processes, leaders then revise their initial conceptualization of the constraint. This reappraisal occurs in the revision stage. At this point, the leader chooses how to manage each constraint (Onarheim, 2012). Based on a case study of Coloplast’s Research and Development Teams, Onarheim (2012) proposed four constraint revision choices made by leaders. These choices include: 1) blackboxing, 2) removal, 3) introduction, and 4) reconceptualization. Blackboxing changes an initially flexible constraint to an inflexible one, allowing leaders and the team to devote no, or little, cognitive resources to this constraint. Removal takes the constraint out of the equation and, again, allows leaders and the team to ignore the constraint. Leaders may also introduce new constraints
to focus the team. This places more cognitive demands on the team as they must consider this information but it may also help guide the team towards a particular goal. Lastly, leaders may re-conceptualize the way a constraint is viewed – changing it from inflexible to flexible.

The revision stage proves especially beneficial for reducing the cognitive demand of constraints. As noted previously, constraints require a great deal of cognitive attention. Together, the aforementioned processes allow leaders to sift through the myriad of potentially influential constraints to determine where to focus one’s attention. Highly fixed constraints, or those that have been blackboxed or removed, may be ignored. This eliminates a set of cognitively consuming constraints thereby allowing leaders and development teams to focus their attention on more flexible constraints.

### Planning

Leaders must next incorporate this highly dynamic, complex, and evolving information into their plans (Anzai, 1984; Mumford, Schulz, & Osburn, 2002; Mumford, Schultz, & Van Doorn, 2001), accounting for more and less flexible constraints. For instance, leaders must incorporate deadlines, production capabilities, and budgets into the plans while accounting for such factors as team and project characteristics, contracts, and relevant field information. Considering the dynamic nature of constraints, this is not an easy task. Leaders must formulate plans while still allowing for flexibility as constraints change throughout the project lifecycle. Some changes may be anticipated and accounted for in planning efforts. Others may arise unexpectedly. In the latter case, plans must adjust to accommodate this new information.

New information and potential constraints arise regularly throughout creative efforts. Therefore, leaders must continuously scan the environment, identify, appraise, forecast, and revise the relevant constraints, and adjust plans as necessary. While this highlights the need for continuous scanning, it also emphasizes the importance of communication. Plans, and changes to these plans, must be communicated with the team.

The highly dynamic nature of constraints and cyclical nature of the model presented here, suggests that leaders of creative efforts must engage in highly flexible thinking in order to successfully manage constraints. A rigid thinking structure fails to allow for the necessary adaptations in plans and thinking. Unfortunately, typical educational interventions tend to focus on declarative knowledge and fail to promote flexible thinking. Its importance to effective leadership of creative efforts, however, points to a need for new teaching methods and interventions emphasizing flexible thinking both within and outside of the classroom. Several potential interventions are provided below.

### LIMITATIONS

Before turning to the conclusions emerging from this discussion, a number of limitations should be noted. First, the empirical literature on constraint management remains scarce. Scholars have only recently begun to examine how leaders might effectively manage constraints involved in creative efforts, and how constraints might differentially impact a project throughout its lifecycle. Thus, the present paper and its propositions should be interpreted with caution—more as an extension of theory that requires future research attention than as a model with substantive empirical support. In addition, due to the large number of potential constraints operating in creative professions, not all constraints could be explored in detail in a single book chapter. For example, personal constraints such as job security and workload
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(Onarheim, 2012) may influence innovative efforts. Although this chapter addresses subcategories within organizational, market, field, and project constraints, other constraints within each of these categories exist. These constraints were beyond the scope of this paper, and indeed, likely beyond the scope of project leaders to act upon directly, but alternative sources of constraints should certainly be explored in future research. Finally, it should be noted that while some constraint interactions were described, it would not have been practical to recognize every potential constraint interaction that may be relevant to the success of creative efforts.

IMPLICATIONS FOR EDUCATION

Despite the limitations noted above, the following model offers several insights into educational efforts for creative leaders. Educational interventions may benefit from targeting specific processes such as scanning, appraising, forecasting, revising, and planning. Indeed, in a meta-analysis of creativity training programs, Scott, Leritz, and Mumford (2004) found trainings focused on cognitive skill development, and on component skills to be particularly effective in creative problem-solving skill development ($r=.33$; $r=.26$). Additionally, the authors found a moderate, positive relationship between constraint identification and creative problem solving and creative performance suggesting some evidence for the efficacy of constraint management education. When teaching leaders, and future leaders, to engage in these processes, dynamic and flexible thinking should be highly emphasized. In other words, simply working through the model in a linear fashion, accounting for only one constraint at a time, is unlikely to result in effective processing. Indeed, to imitate the dynamic nature of creative problem-solving processes, previous research emphasizes the importance of reflective and iterative processes in creative education (Zhou, Kolmos, & Nielsen, 2012). Educational efforts must identify ways for leaders to practice flexible thinking, and, in particular, flexible thinking regarding constraints.

The training literature emphasizes the importance of practice opportunities for knowledge transfer. Transfer refers to the extent to which knowledge, skills, and abilities gained in training transfer to the context in which they are intended to be applied (Goldstein & Ford, 2002). Training transfer is important to consider when discussing creative leader education efforts. After all, educational efforts target improved creativity outside of the classroom – not just behind classroom doors. Thus, students of creative leadership should be given ample practice opportunities, allowing them to see how constraints operate in a real-world setting and to work with and around the constraints themselves. Case-based activities provide one potentially effective method for practice and highlighting the importance of flexible thinking in constraint management. Cases allow students to see how others effectively, or ineffectively, manage situations. In this instance, cases should showcase how leaders effectively gather, sort, appraise, forecast, and apply constraining information in a creative effort. In a study examining different knowledge structures, Hunter, Bedell, Ligon, Hunsicker, and Mumford (2008) compared the influence of associational, conceptual, and case-based knowledge structures on creative problem solving. Participants were trained in one of the aforementioned knowledge structures prior to engaging in a creative problem-solving task. Those in the case-based knowledge condition produced solutions exhibiting greater quality, originality, and elegance in comparison to those in other groups.

In addition to cases, providing students with low- and high-fidelity projects allows them to practice working with and around constraints. Research suggests the importance of realistic practice to creative problem-solving skills (Scott, Leritz, & Mumord, 2004). One example of a realistic practice opportunity

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is a low-fidelity project such as a written assignment where students propose a new product. In this instance, instructors may manipulate the type of constraining information as well as when students receive this information—thereby forcing students to adjust to new information and engage in more flexible thinking. More high-fidelity assignments involve the actual development of an innovation. This may be done in class or for specific competitions such as Microsoft’s Imagine Cup or Insight’s Innovation Competition. These high-fidelity activities provide students with hands-on learning opportunities where they face constraints head on. Additionally, it may be important to provide students with a variety of assignments that allow them to see how constraints operate in different situations. Assignment variety emphasizes the unique influence of constraints across different project settings. This, again, highlights the importance of flexible thinking in constraint management.

The use of low- and high-fidelity activities for constraint management training points to an important implication. Real-world creative projects generally extend beyond a semester’s length and often over the span of several years. This emphasizes the need for long-term, multi-stage projects. Projects such as these may occur over a full semester, where students work through a particular problem, gain feedback, refine their solutions, and move forward. The progress and feedback should be repeated throughout the semester. As an example, Endo, Aoki, Suzuki, Fukushima, and Hirose (2011) describe an engineering course using these methods. In the second semester of their third year, engineering students at a Japanese University designed and built robots. Course instructors monitored the design process through regular group presentations such as “idea presentations,” “technical reviews,” and “mechanical reviews.” At the end of the semester, groups displayed their robots in a “Street Performance Robot Competition.” It is here that students display their robots’ skills such as playing the violin, juggling, performing in a play, and cooking Chinese noodles! At the conclusion of the course, students completed a survey regarding their robot. Approximately 40% of students noted that their final robot was somewhat or very different from their initial design. The students cited restrictions and techniques as the primary reason for changing their initial design. This suggests that high-fidelity situations such as these do, in fact, highlight constraints in the creative process. These types of practice activities enable students to gain a more realistic perspective of how information is gathered and incorporated in creative efforts while strengthening their case-based knowledge.

When designing practice opportunities, the project domain should also be considered. Practice enhances learning and transfer when practice opportunities match the domain in which the learning applies. Specifically, studies of creativity training suggest that trainings may be primarily useful within a particular domain. For instance, after completing Baer’s (1996) divergent-thinking training intervention using poetry exercises, students were asked to write a poem and a story. Students developed more creative poems compared to stories. This suggests that domain specificity matters and should be considered when designing training interventions and subsequent activities.

Given the highly collaborative nature of creative efforts, team activities and processes should also be emphasized. Although not fully discussed in this chapter, teams, and team processes, may introduce an additional level of constraints. For example, Leenders, van Engelen, and Kratzer (2014) argue that knowledge is the foundation for new product development and new knowledge may only be created when information sharing occurs. Thus, communication is a critical component of new product development efforts. Communication is particularly important when managing constraints. As Onharheim (2012) found at Coloplast, individuals and teams may hold their own tacit constraints. Differing assumptions regarding the relevant constraints among team members may lead to inappropriate or inaccurate conceptualizations and therefore unnecessarily limit the range of potential solutions. This further underscores the importance
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of leaders’ communication skills. Leaders must clearly communicate the constraints and how they are to be conceptualized for a particular project. Other interactional and social processes that may impact team creativity include conflict management, goal specification, coordination, and support (Curseu, 2010). Allowing students to practice in teams introduces students to yet another level of constraints, thereby providing students with case-based knowledge of effective or ineffective team processing.

FUTURE RESEARCH

The limited empirical data bearing on constraint management strategies, while presently posing substantive challenges to informing educational interventions, also bears significant opportunities for future research. The propositions in this chapter broach a number of important questions, such as, do the recommended instructional strategies for improving constraint management skills actually prove effective? Specifically, does training students in flexible thinking improve their constraint management? What are the most effective methods for training flexible thinking in constraint management? Further, can leaders be trained to teach these strategies to others? Might training in cross-process strategies (e.g., divergent thinking, forecasting) support the execution of constraint management processes?

As described here, there exist many types of constraints with varying degrees of flexibility, and importance. Future research should investigate the differential impact of each type as well as effective strategies for managing them. Furthermore, understanding how constraints and their influence change over the lifecycle of a project may influence effective leader strategies. This research may also inform how leaders may best conceptualize each constraint throughout the project.

More broadly, future research should continue dissecting how leaders think about and effectively manage constraints in creative efforts. While the present effort provides an initial overview of the constraint management process, the model should be tested in an experimental setting. Furthermore, the research on constraint management would benefit from continued industry research such as Onarheim’s (2012) study that may reveal additional strategies for working with and around constraints in creative endeavors. These questions represent only a small number of potential future research directions in this area.

CONCLUSION

Despite the stereotypical conception of creativity as an unbridled effort, research and practical evidence point to the inherently constrained nature of creative endeavors. Leaders of creative efforts must therefore, manage a complex set of dynamic constraints throughout a creative project’s lifecycle. The present chapter attempts to provide an initial framework for understanding how leaders manage constraints in creative efforts and implications for leader development. As delineated in previous sections, constraints come in many forms such as market, organizational, field, and project constraints. These different types of constraints operate jointly to create a dynamic set of constraints unique to each project and evolving throughout the project lifecycle. Furthermore, this chapter proposes a model of constraint management in creative efforts. Taken together, the model and constraint framework highlight the dynamic nature of constraints, emphasizing the importance of flexible thinking among leaders of creative projects. Lastly, the present chapter addresses potential educational interventions targeting flexible thinking to train lead-
ers in constraint management. While more research is certainly necessary, the present effort provides an initial guiding framework for future work and for educating future leaders of creative efforts.

REFERENCES


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KEY TERMS AND DEFINITIONS

Appraising: Evaluating the extent to which a constraint is malleable and aligns with the current mission.
**Field Constraints:** Limiting factors stemming from the professional field such as fundamentals/themes, networks, maturity, and norms.

**Forecasting:** Considering the potential short- and long-term consequences of a particular constraint.

**Identifying:** Selecting constraints bearing on the current project.

**Market Constraints:** Limiting factors stemming from the market such as competitors, external customers, turbulence, and regulations.

**Organizational Constraints:** Limiting factors stemming from the organization such as fundamentals, internal customers, resources, and production capabilities.

**Planning:** Strategic preparation for future actions.

**Project Constraints:** Limiting factors stemming from the current project such as work characteristics, team characteristics, team climate, and team networks.

**Revising:** Re-conceptualizing the flexibility, or inflexibility, of a particular constraint.

**Scanning:** Searching the environment for potential constraints.
Chapter 3
Scientific Creativity in Psychology:
A Cognitive–Conative Approach

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ABSTRACT
The present research investigates the cognitive and conative profile underlying scientific creativity in psychology. An innovative creativity test including both divergent and convergent thinking was used. Intelligence and personality were also measured. The sample consisted of 121 social science students. Intelligence played a major role for scientific creativity in psychology. With regard to personality, openness and negative agreeableness favored additionally scientific creativity in psychology. In future research, the profile of scientific creativity could be compared with profiles of artistic creativity and everyday creativity.

INTRODUCTION
Batey and Furnham (2006) distinguish between three major domains of creative expression: artistic, scientific and everyday creativity. Although for a long period of time creativity was considered in a domain-general way, presently, creativity is progressively considered to be specific to the respective domain. Both approaches are not necessarily mutually exclusive. According to Lubart, Mouchiroud, Tordjman, and Zenasni (2003), the differential approach to creativity reconciles the domain-general and the domain-specific approach; it assumes that there are both domain-general and domain-specific features for creativity. Whereas according to Batey and Furnham (2006) some cognitive and personality characteristics (e.g., fluid and crystallized intelligence, openness) are supposed to have a domain general importance for creativity, according to Lubart and Sternberg (1995) other features (e.g., knowledge, risk taking) are thought to be more domain-specific. The present chapter aims to investigate the differential DOI: 10.4018/978-1-5225-0643-0.ch003
approach of creativity, with a specific focus on scientific creativity in psychology. The cognitive attributes and the personality characteristics that make up the profile of the scientific creator in the domain of psychology are explored.

BACKGROUND

Scientific Creativity

Although creativity intervenes in many life domains, according to Kaufman and Baer (2006), it is particularly relevant to the arts and sciences. What makes the science discipline so interesting to explore is that it uses a universal language that transcends the different sub-disciplines. Hence, according to them the role of acquired knowledge is secondary for scientific creation.

For Feist (1998), the definition of a scientist includes science students, natural scientists, social scientists, biologists, engineers, inventors and mathematicians. In the 1950s the first serious investigation of the personality profile of eminent scientists in comparison to non-scientists or their less creative peers was conducted (Roe, 1953; Cattell & Drevdahl, 1955; Terman, 1955). However, according to Feist (1993), it is only in the late 1970s and early 1980s that the psychology of science emerged. Feist and Gorman (1998) consider that the importance of this research discipline lies in a fruitful establishment of selection criteria for science students and young researchers. Presently, the personality of scientists is an already well-established area of investigation, using both psychometric tests and biographical analyses (Piirto, 1998).

Gardner (1983) was also interested in the nature of scientific creativity. According to Gardner (1983, p. 138), mathematical creativity refers to the ability to be “absolutely rigorous and perennially skeptical: no fact can be accepted unless it has proven rigorously by steps that are derived from universally accepted principles”. In contrast to this approach, Einstein highlights the intuitive nature of scientific inquiry “to these elementary laws there leads no logical path, but only intuition” (as cited in Holton, 1971-1972, p. 97). In both the scientific and the artistic domains, according to Simonton (2004), chance dominates over logic in the creative process.

Creativity in Psychologists

For Simonton (2013), four different perspectives can be adopted in the analysis of creativity in psychologists. First, creative psychologists can be considered as simply showing one form of expression of high achievement in general, of people who managed to “make history” (Simonton, 1994). Second, creative psychologists can be analyzed together with eminent achievers of various disciplines (Gardner, 1993; Simonton, 1999). Third, creative psychologists can be perceived as belonging to a subgroup of scientific achievers, like physicists, biologists or social scientists (Simonton, 1988). Fourth and last, creative psychologists can be perceived as a category on their own, distinguishing themselves from all other kinds of scientists, creators and achievers (Simonton, 2002). In the present research the third perspective is taken, according to which psychologists and more generally social scientists are perceived as a subgroup of scientists.

According to Auguste Comte (1855), scientific disciplines can be hierarchically organized from more objective and rational to more subjective and intuitive ones. This puts natural sciences on the
top of the hierarchy, followed by social sciences and finally the arts. The lower the domains are on the hierarchy, the more emphasis they put on creativity, according to Simonton (2009). This organization was validated empirically by Simonton (2004) according to several criteria. In this respect, Simonton (2013) argues that psychology is one of the most creative scientific disciplines. According to Simonton (2009), dispositional traits as well as developmental conditions intervene differently in this hierarchy of disciplines. Research confirmed that the personality profile of a “hard” scientist is not necessarily the same as the one of a “soft” scientist. Social scientists (psychologists and anthropologists) in comparison to natural scientists (physicists and chemists) turned out to be more introverted (Chambers, 1964) and more emotional and rebellious (Roe, 1953). It follows according to Simonton (2009) that social scientists can be considered to be on the edge between natural scientists and artists. Still, especially with regard to mental health (Simonton, 1999), according to Simonton (2013), creative psychologists are more comparable to creative scientists than to creative artists. Simonton (2013) considers that the domain of psychology can be further subdivided into the scientific and the humanistic perspective and that the more humanistic oriented psychologists have a profile that is more comparable to the one of artists. Finally, Simonton (2009) argues that the dispositional traits and developmental conditions also determine the degree of success (creativity) in the respective disciplines. In this regard, his domain-regressive hypothesis assumes that the most creative scientists have the personality profile of scientists from fields that are lower in the hierarchy. This means that creative natural scientists rather display the personality profile of a social scientist. In the same line, a creative social scientist has a personality profile that comes closer to one of an artist.

Simonton (2013) made three major conclusions about the creative profile of outstanding psychologists, by directly relating them to eminent achievers from other scientific disciplines, to which they are highly similar. First, creative psychologists have high intelligence, motivation and expertise. Second, they show high productivity, a creative cognitive style and a rather introverted and independent personality. Third, in contrast to eminent artists, eminent psychologists share their relative emotional stability with creative scientists from other disciplines. They have a high probability to be first-born children, who grew up in stable and educated families. Finally, they tend to have had rather successful school careers.

Cognitive Profile of Creative Scientists

According to Feist and Gorman (1998), the psychology of science is divided into four major sub-disciplines: developmental approach, cognitive approach, personality approach, and social approach. As stated above, the present paper will elaborate on the cognitive and personality approach.

In the cognitive approach, Simonton (2002) found that early productivity is an essential condition of later success and recognition in a scientific career, in general and in the domain of psychology. The most creative researchers start publishing before attaining their PhD. A higher productivity rate enhances the chances to produce high quality papers. This is what Simonton (1985) calls the “constant-probability-of-success model”. According to Simonton (2003), the enthusiasm going along with higher productivity prevents researchers from retiring. They just keep on publishing until illness or death sets a final stop to their career.

Batey and Furnham (2006) highlighted the primary role of intelligence for scientific creativity. Even if they consider intelligence as a domain-general feature for creativity, they conceive its influence to be even more pronounced in the scientific domain, regarding both fluid and crystallized intelligence. Regarding eminent psychologists, they share their comparatively high intelligence with eminent achiev-
ers from other disciplines (Simonton, 1994). It follows that a positive relationship between intelligence (logical reasoning and verbal fluidity) and scientific creativity in psychology is expected.

**Personality Profile of Creative Scientists**

The *personality approach* deals with: (1) establishing differences between scientists and non-scientists, (2) comparing more and less outstanding scientists, (3) comparing the personality profile of scientists from different theoretical orientations, and finally (4) predicting scientific behavior by personality. With regard to the first two points, the personality psychology of arts and sciences is usually divided into the between-group and within-group perspectives. Whereas the *between-group* perspective deals with the distinguishing features of artists and scientists from non-artists and nonscientists, the *within-group* perspective accounts for the differences between more and less creative professionals within one domain. Seeing that according to Feist (1998) non-creative artists have little chance to succeed, the intragroup variability is much smaller in arts than in sciences. In the personality approach, according to Feist and Gorman (1998), a fairly consistent profile of the scientific personality emerged from a long period of empirical research. This holds true for the comparison of scientists to non-scientists (between-group perspective) as well as for the comparison of more and less creative scientists (within-group perspective).

The Big Five model (Costa & McCrae, 1985, 1989, 1992), which gained popularity in the 80’s and 90’s, assumes the presence of five major personality factors: Neuroticism (N), Extraversion (E), Openness to new experiences (O), Agreeableness (A) and Conscientiousness (C). In the Big Five approach, Feist’s (1998) meta-analysis revealed that scientists as compared to non-scientists are more open, more extraverted (confident-dominant) and more conscientious. Creative scientists as compared to less creative ones are more open, extraverted and less conscientious (higher expression of needs and higher psychopathic deviance subcomponents). The distinction in extraversion between more and less creative scientists applied only to the confidence-dominance subcomponent and not to the sociability component. In the Big Three personality model, Eysenck (1990) assumes the presence of three higher-order personality factors: Extraversion versus Introversion (E), Emotional stability versus Neuroticism, and Psychoticism versus Impulse control (P). In the Big Three approach, Feist (1998) found scientists as compared to non-scientists to be more extraverted and higher on psychoticism. Summarizing the Big Five and Big Three approach, Batey and Furnham (2006) consider that the profile of the scientific creator is characterized by low neuroticism (high ego-strength), low extraversion (high introversion), high openness, high conscientiousness and moderately high psychoticism (see Table 1).

Taken together, in the *between-group* perspective, as compared to non-scientists, scientists turned out to be (1) more conscientious, (2) more dominant, achievement oriented and driven, (3) more independent, introverted, and less sociable, and (4) more emotionally stable and impulse controlled (Feist & Gorman, 1998). Similarly, in the *within-group* perspective, eminent scientists in comparison to less eminent scientists were (1) more dominant, arrogant, self-confident, or hostile (social traits), (2) more autonomous, independent, or introverted (social traits), (3) more driven, ambitious, or achievement oriented (nonsocial traits), and (4) more open and flexible in thought or behavior (nonsocial traits) (Feist, 1999; Feist & Gorman, 1998). Hence, according to Feist (1999), the distinction between more and less creative scientists lies in social as well as nonsocial traits. In the present research, the within-group perspective is adopted.

The higher *conscientiousness* of scientists as compared to non-scientists (Feist, 1998; Feist & Gorman, 1998) as well as the stated importance of conscientiousness for scientific creativity (Batey & Furnham,
Scientific Creativity in Psychology

Table 1. Representation of typical profiles for creativity in different domains (Batey & Furnham, 2006, p. 409).

<table>
<thead>
<tr>
<th>Trait</th>
<th>Artistic Creativity</th>
<th>Scientific Creativity</th>
<th>Everyday Creativity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intelligence</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fluid</td>
<td>+</td>
<td>++</td>
<td>+</td>
</tr>
<tr>
<td>Crystallized</td>
<td>++</td>
<td>++</td>
<td>+</td>
</tr>
<tr>
<td>Personality</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>N</td>
<td>++</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>E</td>
<td>-</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>O</td>
<td>+ +</td>
<td>+ +</td>
<td>+ +</td>
</tr>
<tr>
<td>A</td>
<td>-</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>C</td>
<td>-</td>
<td>+ +</td>
<td>+</td>
</tr>
<tr>
<td>P</td>
<td>+ +</td>
<td>+</td>
<td>+</td>
</tr>
</tbody>
</table>

Note. N = neuroticism; E = extraversion; O = openness to experience; A = agreeableness; C = conscientiousness; P = psychoticism. Positive and negative signs indicate the strength and the direction between the variables and range from -- -- to ++ ++.

2006; see Table 1) makes sense when considering the highly structured and systematized nature of scientific inquiry. However, in comparison to less creative scientists, creative scientists were found to be less conscientious (Feist, 1998). Hence, the actual influence of conscientiousness on scientific creativity is somehow ambiguous. Considering this fact, no assumption is presently made on the direction of the relationship between conscientiousness and scientific creativity in psychology.

Presently, the dominant, arrogant, self-confident, or hostile attitude of eminent scientists (Feist, 1999; Feist & Gorman, 1998) is referred to as psychoticism and low agreeability. Indeed, Eysenck (1993, 1995) describes individuals high on psychoticism as aggressive, cold, egocentric, impersonal, impulsive, antisocial, non-empathic and tough minded. Eysenck considers psychoticism as a normally distributed personality trait, which according to Batey and Furnham (2006) (see Table 1) intervenes significantly in scientific creativity just like low agreeableness. Even though, scientists in general tend to be more asocial and individualistic than the general population, these traits are even more pronounced in the scientific elite (Feist & Gorman, 1998). According to Simonton (2004), these behaviors can be related to their social and professional marginality. Not only do creative scientists often come from multicultural family backgrounds but they are also skilled in more than one scientific discipline. This indicates that switching between disciplines is not necessarily counterproductive. Simonton considers that the outside perspective permitted by marginality allows creative scientists to have some kind of naïve objectivity which simplifies the innovative combination of disseminated elements. Even though eminent psychologists were found to be more emotionally stable than eminent artists (Ludwig, 1995; Simonton, 2002), they show still some tendencies towards psychopathology (Rushton, 1990). It follows that the influence of psychoticism and negative agreeability is hypothetically extended to scientific creativity in psychology.

The higher emotional stability and impulse control of scientists as compared to non-scientists (Feist & Gorman, 1998) is presently referred to as ego-strength. Indeed, according to Eysenck (1995) ego-strength is best conceptualized as emotional stability, which is the opposite on the neuroticism scale. Neuroticism, again, is assumed to have a negative impact on scientific creativity by Batey and Furnham (2006) (see Table 1). Presently, higher ego-strength is also considered to determine the driven, ambi-
tious and achievement oriented behavior of the more creative scientists in comparison to the less creative ones (Feist, 1999; Feist & Gorman, 1998). According to Simonton (2013), creative psychologists share their comparably higher emotional stability with creative scientists. In this sense, a positive relationship between ego-strength and scientific creativity in psychology is expected.

In the present research, the autonomy, independence, introversion and low sociability of creative scientists (Feist, 1999; Feist & Gorman, 1998) are considered as autonomy-related personality features in reference to Oztunc (2011). Also creative psychologists embody a rather independent personality according to Simonton (2013). It follows that a positive relationship between autonomy and scientific creativity in psychology is expected.

Introversion and low sociability directly relate as well to Big Five extraversion, whose influence on scientific creativity is somewhat ambiguous. According to Batey and Furnham (2006) (see Table 1) extraversion plays a negative role in scientific creativity. However, especially when it comes to comparing scientists to non-scientists and more creative scientists to less creative scientists, results are incoherent. Whereas in Feist (1999) and Feist and Gorman (1998), introversion distinguished scientists from non-scientists and more creative scientists from less ones, in Feist (1998) scientists as compared to non-scientists and more creative as compared to less creative scientists distinguished themselves through comparatively higher extraversion. This latter finding however only referred to the confidence dimension (confident-dominant) and not to the sociability dimension. The relationship between extraversion and scientific creativity seems to vary according to the considered dimension (confidence/sociability). Regarding psychologists, the results are probably even more clear. Even if creative psychologists can be considered as introverted, they are still more extroverted than scientists from other disciplines (Cattell, 1963) and they lead more active and less conventional social lives, in regard to leisure activities and romantic relationships (Roe, 1953). Despite some ambiguities concerning the relationship between extraversion/introversion and scientific creativity, with reference to Simonton (2013), a positive association is expected between introversion and scientific creativity in psychology.

Openness and flexibility in thought and behavior of creative scientists (Feist, 1999; Feist & Gorman, 1998) are presently referred to as Big Five openness to new experiences. According to Batey and Furnham (2006) (see Table 1), openness has a domain transcendent importance for creativity. This anticipated domain general importance is extended to the subdomain of social sciences. Consequently, a positive correlation between openness and scientific creativity in psychology is expected.

**Measurement of Scientific Creativity**

Scientific creativity can be analysed as the ability to generate hypotheses, design experiments and proof of evidence. Before tests were available, scientific creativity of eminent scientists was sometimes measured through the number and importance of their publications. Today, specific tests are being developed for scientific creativity, but this remains rare. An example is the Creative Scientific Ability Test (C-SAT) for 6 to 8 graders. The C-SAT consists of three dimensions of skills: general-creativity skills, science-related skills and skills in scientific sub-disciplines (Sak, 2010; Sak & Ayas, 2013). Presently, the Evaluation of Potential Creativity EPoC (Lubart, Besançon, & Barbot, 2011) is one of the few tests available for the assessment of scientific creativity in students and adolescents. This test specifies two aspects of the creative thinking process that are simultaneously assessed: divergent exploratory thinking (invention of multiple responses to one stimulus) and convergent integrative thinking (development of one single most creative response).
RESEARCH AIMS AND HYPOTHESES

The cognitive attributes and personality characteristics that are important for scientific creativity in psychology are the focus of the present research. Former studies investigated especially illustrious psychologists who were selected according to objective scientific outcomes (productivity and/or eminence) (Rushton, 1990; Simonton, 1988, 1994, 1999, 2002). The present study aims to extend these results to the typical social science student. As former scientific creativity tests focused solely on natural sciences, the development of a specific test for scientific creativity in psychology enlarges their domain of applicability to the social sciences. This test is a new innovation in the sense that both divergent and convergent creative thinking are measured in the domain of scientific psychology. This allows investigating the creative profile in social science students, who do not yet have some kind of productivity rate. The above literature review leads to the following hypotheses.

1. Intelligence is expected to be a positive predictor of scientific creativity in psychology.
2. Ego strength is expected to be a positive predictor of scientific creativity in psychology.
3. Introversion is expected to be a positive predictor of scientific creativity in psychology.
4. Openness is expected to be a positive predictor of scientific creativity in psychology.
5. Agreeableness is expected to be a negative predictor of scientific creativity in psychology.
6. Psychoticism is expected to be a positive predictor of scientific creativity in psychology.
7. Autonomy is expected to be a positive predictor of scientific creativity in psychology.

METHODS

Participants

The sample of social science students included 121 participants (95 women, 24 men, $M_{\text{age}} = 21.94, SD = 2.22$, age range: 19-32). The condition of participation was to be a student/graduate student in a social science discipline as well as mastering the German language. The majority were psychology students (87.6%), followed by students in education (7.4%) and students from various other social science disciplines (4.9%). The sample only included 4.13% postgraduate students (who had already acquired a Master’s degree). Participants’ mother tongue was German (47.1%), followed by Luxembourgish (34.7%), “Other” (13.2%) and French (5%).

Materials

In the present research a specific test for the measurement of scientific creativity in the domain of psychology was developed.

The development of the test for scientific creativity in psychology was strongly inspired by the EPoC (Lubart et al., 2011). Momentarily, the EPoC is applicable to three creative domains: verbal, graphic and scientific. The present test potentially enlarges its applicability to the sub-domain of social sciences and more specifically to psychology. Considering that divergent thinking alone is insufficient to measure creativity, convergent-integrative thinking is additionally taken into account. Divergent thinking was assessed by the invention of a maximum number of original and appropriate hypotheses regarding
the link between “music style and personality”. Convergent thinking was assessed by the invention of an ingenious psychological experiment to test one of the formerly-generated hypotheses. The rating of convergent thinking was inspired by the Consensual Assessment Technique (CAT) (Amabile, 1982, 1983). The experiments were rated by 3 independent expert judges on a 7-point Likert scale. There was no absolute criterion for the judgment; the proposed experiments were simply rated against each other. The order of presentation varied for each judge. Inter-rater reliability was .76 (Cronbach Alpha). The rating of convergent thinking was further subdivided into originality and usefulness (adaptation), with reference to the consensual creativity definition. The experiment did not only need to be original but also adapted to methodological requirements. It needed to satisfy methodological and ethical standards and to be empirically realizable.

In order to assess its convergent validity, general creative potential was measured by the Test for Creative Thinking-Drawing Production (TCT-DP) (Urban & Jellen, 1995). The TCT-DP was scored according to three different evaluation techniques that are outlined below. Lubart, Jacquet, Pacteau, and Caroff (2010) consider the TCT-DP as an essentially convergent-integrative measure of creative potential. According to Urban (2005), this constraint production task which is inspired by the “Gestalt” approach can be considered as culture fair. It was normed and validated in various countries and it is applicable to a variety of age and ability groups.

The traditional scoring method includes 14 criteria: continuations; completion; new elements; connections with a line; connections with a theme; boundary breaking -fragment-dependent; boundary breaking-fragment-independent; perspective; humor and affectivity; four kinds of unconventionality and speed. According to Urban (2005), these sub-scores taken separately do not meaningfully represent creativity because the “Gestalt” emerges from a synergy of individual elements. An inter-rater reliability of $\alpha = .98$ (Cronbach Alpha) was established for this scoring method in the present investigation. With reference to Lubart et al. (2010), the traditional scoring method of the TCT-DP is represented by two factor scores: the originality factor OF and the adaptation factor AF. The AF includes the number of new items added to the composition, contacts and thematic connections established between the initial graphic elements, use of unconventional, non-stereotyped content or graphic forms, creation of a humorous or emotional atmosphere and the use of three-dimensional drawing techniques. The OF comprises the number of graphic elements used among the initial elements proposed as well as their meaningful use and the use of the element outside the frame.

In the present research, a second originality score was considered: Statistical Originality SO. It represents the statistical percentage of a given idea within the reference sample. According to Lubart et al. (2010), this score is very similar to the originality score calculated in divergent thinking tests. Thus, this adds a divergent thinking score to the overall convergent-integrative TCT-DP measure.

Finally, the third evaluation technique was inspired by the Consensual Assessment Technique (CAT) from Amabile (1982, 1983). With reference to Lubart et al. (2010), two suitable expert judges were asked to rate independently the creativity degree of the manufactured products on a 7-point scale, without receiving a prior definition of creativity. The random order of the presented drawings varied for every judge. The present inter-rater reliability (Cronbach Alpha) was $\alpha = .89$.

*Intelligence* was assessed in terms of logical reasoning and verbal fluency. Both scores were significantly correlated ($r = .27, p < .01$) and were added to yield an intelligence sum score. *Reasoning capacity* was assessed by the test of Evaluation of Logical Reasoning (B53) (Bonnardel, 1971). Inductive reasoning and spatial aptitudes are evaluated by means of non-verbal items, in which the test taker is requested to discover the logic behind a series of figures. Inductive reasoning is crucial for tasks of classification,
learning, problem solving and creation. The internal consistency (Cronbach Alpha) in the present sample was $\alpha = .86$. *Verbal fluency* was assessed by the “Verbal Creativity Test” (Verbal Kreativitätstest, VKT) from Schoppe (1975). In this test the initial letters of a word are provided. Participants have 90 seconds to find as many alternatives as possible to complement the initial letters. As two different word-beginnings are provided, the test takes 180 seconds to complete. This test was administered in German, as this was the mother tongue of the majority of participants. All invented words are acceptable as long as they are included in the German dictionary. They can either start in upper case or lower case letters and they can also include names. Foreign words are allowed as long as they have been adopted into the German language. Verbal fluency tests have at times been perceived as hybrid measures of fluid and crystallized intelligence (Lindenberger & Baltes, 1997; Salthouse, 1993).

*Big Five personality* was assessed through the BFI-10 (Rammstedt & John, 2007), a 10-item short version of the NEO-FFI. These 10 short statements are responded to on a five point Likert scale (1 = “disagree strongly” to 5 = “agree strongly”). There are respectively two items per Big Five dimension, which were chosen according to different criteria: (1) they meaningfully represent the opposites of every dimension, (2) they both grasp key aspects of every dimension, without being repetitive, (3) the chosen German and English items are identical, and finally (4) the item choice is based on the statistical criteria of item analyses and factor analyses. According to the authors, convergent validity as well as reliability of the scale is good (mean $\alpha = .75$).

In addition to the BFI-10, the entire dimension of *Openness to new experiences*, which includes 48 items, was assessed by the NEO-FFI (Costa & McCrae, 1992). The Openness dimension includes six different facets, which represent different spheres of experience towards which the participant can be more or less open. People high on openness are more curious towards inner and outer experiences, which become more vivid and enrich their lives. They have more intense emotions, more ingenious ideas, more unconventional values and they are more likely to question authority. Presently, the scale showed an internal consistency of $\alpha = .84$.

*Autonomy* was assessed by two different measurement tools, which showed a highly significant one-tailed inter-correlation ($r = .25$, $p < .01$) and were thus combined in form of a sum score. The “Trier Personality Inventory” (Trierer Persönlichkeitsfragebogen, TPF) is a 120-item questionnaire from Becker (1989). It grasps the two most important aspects of mental health and behavioural control, underlying a systemic model of personality. This model is based on theories, systemic reviews (Becker & Minsel, 1986), and factor analytic studies (Becker, 1995, 2000). Mental health is defined as the capacity to deal with external and internal psychological distress (Becker, 1989). The TPF is applicable in clinical settings and normed for adults between 18 and 80. An alpha coefficient of .78 was found in the present sample. The second autonomy scale was originally developed by Ibarra and Andrews (1993) and later adapted by Dewett (2006). This scale captures the degree of management control in the working environment. The five-point Likert scale ranges from 1 (strongly disagree) to 5 (strongly agree). A Cronbach alpha coefficient of .74 was observed in the present sample.

*Ego-strength* was assessed by the Minnesota Multiphasic Personality Inventory (MMPI-2) (Hathaway & McKinley, 1996, 2000) through the subscale Ego-strength (Es). According to the authors, The Es-scale is a measure of adaptability, resilience, personal resources and effective life management. It stands as an indicator of general mental health, expressed by the capacity to deal with critical life situations and solve problems. People high on Es are spontaneous, have good contact to reality, a feeling of personal success and of physical health. In the present research, the scale had an internal consistency of $\alpha = .66$. 
Psychoticism was assessed by the short form of the Eysenck Personality Questionnaire- Revised (EPQ-R) (H. J. Eysenck & Eysenck, 1992). It captures three major personality dimensions: Extraversion vs. Introversion, Neuroticism or “Emotionality”, and Psychoticism or “Tough Mindedness”. The term “Tough Mindedness” is preferred over Psychoticism, just to exclude any psychiatric assimilation. These people tend generally to be cruel, inhumane, socially indifferent, hostile, aggressive, insular, glacial, intolerant and non-considerate of danger. They tend to create distress in other people’s lives through their lack of empathy, their condescending attitude and their troublemaking behavior. In the present research, the scale had an internal consistency of $\alpha = .60$.

Procedure

Data was collected by psychology students at the University of Luxembourg. The testing was individual or semi-collective. The tests and questionnaires took approximately one and a half hour to complete. First, the creativity test (TCT-DP) was administered, followed by the intelligence tests (Reasoning B53 and VCT), the scientific creativity test and the personality questionnaires (autonomy, Big Five, ego-strength and psychoticism). All participants were volunteers and were compensated for their participation with a little gadget and with the possibility to obtain feedback on their results.

RESULTS

Descriptive Statistics

Correlations and Regressions

Hypotheses will now be reconsidered separately:

1. Intelligence is expected to be a positive predictor of scientific creativity in psychology.

   This hypothesis was supported. Intelligence was a positive predictor of scientific creativity in psychology ($\beta = .18, p < .05$), especially convergent thinking ($\beta = .20, p < .05$) and originality ($\beta = .23, p < .05$).

2. Ego strength is expected to be a positive predictor of scientific creativity in psychology.

   This hypothesis was not supported. Ego-strength was not a positive predictor of scientific creativity in psychology in either form of its measurement (see Table 3 and 5).

3. Introversion is expected to be a positive predictor of scientific creativity in psychology.

   This hypothesis was not supported. Introversion was not a positive predictor of scientific creativity in psychology (see Table 3 and 5). There was even one positive correlation between scientific creativity (adaptation) and extraversion ($r = .16, p < .05$), which did not remain significant in multiple regressions.
### Table 2. Means and standard deviations for personality and cognitive creativity variables

<table>
<thead>
<tr>
<th>Variables</th>
<th>M</th>
<th>SD</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scientific Creativity</td>
<td>13.91</td>
<td>3.79</td>
<td>3</td>
<td>26</td>
</tr>
<tr>
<td>Divergent Creativity</td>
<td>4.42</td>
<td>2.20</td>
<td>0</td>
<td>12</td>
</tr>
<tr>
<td>Convergent Creativity</td>
<td>9.49</td>
<td>2.63</td>
<td>2</td>
<td>16</td>
</tr>
<tr>
<td>Originality</td>
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<td>2.94</td>
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<td>16</td>
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<tr>
<td>Adaptation</td>
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<td>2</td>
<td>16</td>
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<td>79</td>
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<td>15.99</td>
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<td>199</td>
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<td>10</td>
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<td>1.67</td>
<td>2</td>
<td>9</td>
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<td>Ego-strength</td>
<td>34.25</td>
<td>4.95</td>
<td>23</td>
<td>46</td>
</tr>
</tbody>
</table>

**Note.** Scientific Creativity: Sum score of divergent and convergent creativity in the domain of psychology; Divergent Creativity: Number of creative hypotheses invented; Convergent creativity: Rated creativity of the invented psychological experiment (Originality and Adaptation); Originality: Innovative aspect of the invented experiment; Adaptation: Meaningfulness of the invented experiment.

### Table 3. Correlation matrix of personality and cognitive variables with scientific creativity in psychology

<table>
<thead>
<tr>
<th>Variables</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
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<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
<th>13</th>
<th>14</th>
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<tbody>
<tr>
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<td>1</td>
<td>.74**</td>
<td>.83**</td>
<td>.70**</td>
<td>.63**</td>
<td>.18*</td>
<td>.07</td>
<td>.12</td>
<td>.06</td>
<td>-.16*</td>
<td>.00</td>
<td>- .03</td>
<td>.05</td>
<td>.08</td>
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<td>2. Divergent Creativity</td>
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<td>.15</td>
<td>.09</td>
<td>.15</td>
<td>.07</td>
<td>-.10</td>
<td>.07</td>
<td>.03</td>
<td>-.22**</td>
<td>.05</td>
<td>-.02</td>
<td>.02</td>
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<td>.13</td>
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<td>3. Convergent Creativity</td>
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<td>.76**</td>
<td>.20*</td>
<td>.10</td>
<td>.10</td>
<td>.12</td>
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<td>.03</td>
<td>.05</td>
<td>.05</td>
<td>.09</td>
<td>.13</td>
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<td>4. Originality</td>
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<td>.23**</td>
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<td>.02</td>
<td>-.07</td>
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<td>-.05</td>
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<td>.06</td>
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<td>.18*</td>
<td>.19*</td>
<td>.16*</td>
<td>-.01</td>
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<td>.02</td>
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<td>-.17*</td>
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<td>8. Openness</td>
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<td>.31**</td>
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<td>.06</td>
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<td>.21*</td>
<td>.21*</td>
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<td>14. Ego-strength</td>
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<td>.10</td>
<td>.10</td>
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<td>.10</td>
<td>.10</td>
<td>.10</td>
<td>.10</td>
<td>.10</td>
<td>.10</td>
</tr>
</tbody>
</table>

**Note.** * p < .05 level; ** p < .01 level.
Scientific Creativity in Psychology

4. **Openness** is expected to be a positive predictor of scientific creativity in psychology.

This hypothesis was supported. Openness was a significant predictor of scientific creativity in psychology, in form of adaptation (β = .19, *p* < .05).

5. **Agreeableness** is expected to be a negative predictor of scientific creativity in psychology.

### Table 4. Correlation matrix of different creativity variables

<table>
<thead>
<tr>
<th>Variables</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. TCT-DP</td>
<td>1</td>
<td>.95**</td>
<td>.38**</td>
<td>.72**</td>
<td>.64**</td>
<td>.16</td>
<td>.11</td>
<td>.20*</td>
<td>.13</td>
</tr>
<tr>
<td>2. OF</td>
<td>1</td>
<td>.33**</td>
<td>.45**</td>
<td>.70**</td>
<td>.18</td>
<td>.08</td>
<td>.21**</td>
<td>.13</td>
<td></td>
</tr>
<tr>
<td>3. SO</td>
<td>1</td>
<td>.33**</td>
<td>.37**</td>
<td>.00</td>
<td>.03</td>
<td>.09</td>
<td>.04</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. AF</td>
<td>1</td>
<td>.26**</td>
<td>.05</td>
<td>.12</td>
<td>.11</td>
<td>.08</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. CAT</td>
<td>1</td>
<td>.18</td>
<td>.09</td>
<td>.08</td>
<td>.11</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Divergent Psychological Creativity</td>
<td>1</td>
<td>.15</td>
<td>.09</td>
<td>.15</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. Convergent Psychological Creativity</td>
<td>1</td>
<td>.45**</td>
<td>.55**</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. Originality</td>
<td>1</td>
<td>.19*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>9. Adaptation</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Note. * *p* < .01 level; **p* < .01 level; TCT-DP: Test for Creative Thinking-Drawing Production; OF: Originality factor (sub score of TCT-DP); SO: Statistical originality; AF: Adaptation factor (sub score of TCT-DP); CAT: Consensual assessment technique.*

### Table 5. Predictors of scientific creativity in psychology

<table>
<thead>
<tr>
<th>Predictor</th>
<th>ΔR²</th>
<th>β</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Scientific Creativity Sum Score</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Model 1</td>
<td>.03</td>
<td></td>
</tr>
<tr>
<td>Intelligence</td>
<td></td>
<td>.18*</td>
</tr>
<tr>
<td><strong>Divergent Creativity</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Model 1</td>
<td>.04</td>
<td></td>
</tr>
<tr>
<td>Agreeableness</td>
<td></td>
<td>-.22*</td>
</tr>
<tr>
<td><strong>Convergent Creativity</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Model 1</td>
<td>.03</td>
<td></td>
</tr>
<tr>
<td>Intelligence</td>
<td></td>
<td>.20*</td>
</tr>
<tr>
<td><strong>Originality</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Model 1</td>
<td>.04</td>
<td></td>
</tr>
<tr>
<td>Intelligence</td>
<td></td>
<td>.23*</td>
</tr>
<tr>
<td><strong>Adaptation</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Model 1</td>
<td>.03</td>
<td></td>
</tr>
<tr>
<td>Openness</td>
<td></td>
<td>.19*</td>
</tr>
<tr>
<td>n</td>
<td>120</td>
<td></td>
</tr>
</tbody>
</table>

*Note. * *p* < .05 level; **p* < .01 level.*
Scientific Creativity in Psychology

This hypothesis was supported. Agreeableness was a negative predictor of scientific creativity in psychology, as measured through divergent thinking ($\beta = -.22, p < .05$).

6. **Psychoticism** is expected to be a positive predictor of scientific creativity in psychology.

   This hypothesis was not supported. For scientific creativity in psychology psychoticism played no apparent role (see Table 3 and 5).

7. **Autonomy** is expected to be a positive predictor of scientific creativity in psychology.

   This hypothesis was partially supported. Autonomy was not a significant predictor of scientific creativity in psychology in multiple regressions (see Table 5) but there was a positive correlation between autonomy and scientific creativity in psychology (adaptation) ($r = .18, p < .05$).

**CONCLUSION**

Concerning the convergent validity of the test developed to measure scientific creativity in psychology, correlations with drawing creativity scores (TCT-DP) were consecutively positive, even if they were rather low (see Table 4). It was especially the originality component of the invented psychological experiment (convergent thinking) that correlated with various scores of the TCT-DP. Indeed, the lower association with divergent scientific creativity could related to the fact that the TCT-DP is a convergent-integrative creativity test. Results would eventually be different by comparing divergent scientific thinking to a common divergent-focused thinking test. At this point it is important to highlight that even though the TCT-DP is a test about visual rendering it addresses global imaginary thinking processes that intervene in general creativity. In this sense more significant positive associations could have been expected. On the other hand, the positive association of scientific creativity task scores with different personality traits that are theoretically expected to be related to scientific creativity (openness and negative agreeableness), argue again in favor of its construct validity.

Intelligence (logical reasoning and verbal fluency) turned out to be the most important predictor of scientific creativity in psychology (see Table 5). This finding is not surprising and reconfirms the theoretical literature review of Batey and Furnham (2006) (see Table 1), according to which fluid and crystallized intelligence are essential for scientific creativity. It can be argued in reference to Mednick (1962) that for making creative research contributions, it is essential to have a large knowledge base stored in long term memory (crystallized intelligence), which needs to be used in an efficient and innovative way. This is where fluid intelligence intervenes. In the present case, intelligence was particularly relevant for convergent thinking and originality. Indeed, for a long time, intelligence was assessed through convergent thinking tasks whereas creativity was essentially assessed through divergent thinking tasks, which according to Runco, Dow and Smith (2006) led to an overestimation of their difference. In this sense, the stronger relation between intelligence and convergent creative thinking is understandable. Also, the relationship between intelligence and originality is comprehensible if one considers that originality (“successful novelty”) was at times considered as the core of the definition of intelligence (e.g., Gardner & Sternberg, 1994; Gregory, 1981; Spearman, 1927; Sternberg, 1985). Empirically, among the divergent thinking scores, originality was again found to have the strongest relationship with intelligence.
(Benedek, Franz, Heene, & Neubauer, 2012). However, according to the theory of successful intelligence (Sternberg, 2005), which includes the importance of flexible adaptation to changing situations, one could have expected a positive relationship to adaptation as well.

The present results revealed that openness was related to the adaptation of the psychological experiment to methodological constraints (see Table 5). This further corroborates the assumption that personality influences differently both aspects of creativity, which are originality and adaptation. However, the influence of openness on creativity does not seem to be necessarily predominant for the innovative aspect of a production, as hypothesized by Kwang et al. (2005). This is somewhat surprising because openness is considered as a basic exploratory tendency. Together with extraversion it belongs to the “Plasticity” dimension from De Young, Peterson, and Higgins (2002), which is closely linked to low latent inhibition (Peterson & Carson, 2000; Peterson, Smith, & Carson, 2002). In this sense, one could have expected openness to be more important for making original research contributions rather than adapted ones. However, depending on task demands, the role of openness seems to vary. Eventually, the higher cognitive flexibility that goes along with Plasticity may have enhanced the reactiveness to task constraints (adaptation). In any case, the importance of openness for scientific creativity confirmed further the domain general importance of openness for creativity. This supports not only the literature review of Batey and Furnham (2006) but also Feist’s meta-analysis (1998) on the role of personality (openness) in different forms of creativity and more specifically in scientific creativity (Feist, 1999; Feist & Gorman, 1998).

Another personality trait that was relevant to scientific creativity was low agreeableness (see Table 5). It was important for generating a high number of creative hypotheses concerning the link between music style and personality. This means that creative social science students in this case were not particularly socially welcoming. This outcome seems intuitively plausible. It confirms the theoretical literature review of Batey and Furnham (2006) (see Table 1) and the empirically established low sociability or hostility of scientists in comparison to non-scientists and of creative scientists in comparison to less creative ones (Feist, 1999; Feist & Gorman, 1998). This outcome is also consistent with Feist’s (1993) model, in which observer-rated hostility and an arrogant working style predicted scientific eminence. Presently, this result can be interpreted in the sense that less agreeable people can more easily overcome social barriers, which would normally hinder the invention of more unusual experiments. Indeed, disagreeable people would probably be more willing to put participants in unethical experimental conditions in order to test uncommon hypotheses. It is true that some kind of experimental designs can push the limit of moral considerations. Less agreeable people might also think less in stereotypes because in the end the link between music and personality is quite stereotype loaded.

Taken together, the creative social science student is characterized by intelligence and openness but nevertheless is somewhat disagreeable. Considering the fact that none of the above hypotheses was clearly contradicted, it can be concluded that the profile of creative social science students is coherent with the one of outstanding psychologists (Simonton, 2002, 2013) and that the creative profile in social sciences stays in line with the creative profile in “hard” sciences (see Table 1). However, the established profile distinguished itself slightly from the expected one, in the sense that ego-strength, introversion, psychoticism and autonomy were less involved in the scientific creative process than expected. One explanation for these discrepant results could be that the present sample did not include outstanding psychologists in contrast to former research (Simonton, 2002, 2013).

However, the meta-analysis from Feist (1998) did also include students from the social sciences (i.e., psychology) and revealed higher psychoticism on the EPQ in scientists versus non-scientists as well
as higher Achievement via Independence on the California Personality Inventory (CPI) in scientists versus non-scientists and in creative scientists versus less creative scientists. The present results can seem surprising if one considers the fact that theoretically speaking the lack of empathy which accompanies psychopathological tendencies could be fruitful for inventing outlying hypotheses and unusual circumstances to test them. In the same vein, one could have imagined that autonomy and the related independence intervene in the capacity to invent creative hypotheses and research ideas in psychology. It is nevertheless understandable that the aggressiveness, hostility and ego-centricity, along with high psychoticism, are even more pronounced in creative professional psychologists (especially researchers) than in creative social science students. One could argue that exactly those specific features help creative psychologists to reach the status of eminence. The same assumption could be made about the various autonomy-related personality features and ego-strength. In outstanding psychologists, pronounced emotional stability (ego-strength) seems unavoidable in order to counterbalance the lack of impulse control (psychoticism). Indeed, it was especially found in eminent creators that both tendencies (psychoticism and ego-strength) occurred (Eysenck, 1995; Post, 1994). This unusual combination of traits did not, however, extend to creative social science students.

Regarding the fact that previous results concerning introversion/extraversion in scientists/psychologists were ambiguous, the present finding is not particularly surprising. One could conclude that the introversion/extraversion dimension does not play such a prominent role for scientific creativity. Apparently, it is possible to be a creative natural or social scientist without having the tendency to regularly withdraw from social situations. It could be argued that especially in the science discipline a healthy amount of interaction among researchers/professionals is fruitful for creative scientific contributions. This could be referred to the necessary perspective taking emphasized in constructivist theories (Järvelä & Häkkinen, 2002).

**IMPLICATIONS FOR HIGHER EDUCATION FOR CREATIVE PSYCHOLOGISTS**

"Without great solitude, no serious work is possible" (Picasso as cited in Cain, 2013).

Many scholars in the domain of creativity and education have developed ideas for fostering creativity in schools. Approaches vary from political and organizational ones to suggestions for changing curricula, and teacher training. Cropley (2015) for example outlines detailed strategies for designing engineering curricula. He explains that there is however another hurdle to overcome. There is a movement from generic to general learning. The constructivist approach of contextualized or generalized learning has replaced generic or decontextualized learning. Only decontextualized learning however allows the deduction of principles and applying problem-solving rules in other contexts. The learning of generic skills needed for creativity is therefore at risk. Results are students with ‘pseudo expertise’ according to Sternberg (2003), using routinely procedural knowledge but not adaptive expertise. Sternberg (2015) states also that we are still far away from our goals, because it is the experts themselves of various fields who should first integrate and accept the knowledge on teaching for creativity, which is the hardest to achieve. Interestingly, few approaches actually describe the students themselves, other than viewing them as learning objects, and their role in the changes needed. Overall it seems that there are yet many difficulties to overcome at all levels of higher education, before creativity is an evident ingredient. According to Sternberg (2015), a university-wide belief is needed. All leaders and adults that make up the university should be convinced of a needed change and the collaboration of all parties is the aim.
Today, collaboration is also identified as an important skill for the 21st century. According to the Partnership for 21st Century Learning (P21, 2010), it is important to prepare students among other skills to become good communicators and collaborators as well as creative problem solvers. Sawyer states this as well (2012, p. 212): “today more than ever, the most important forms of creativity are” for example “big science experiments” with “cooperative activities of complex networks of skilled individuals.”

The collaboration and creativity skills needed for the working world put creative collaboration in higher education at the forefront as well. This again fosters the socio-cultural research that emphasizes the collaborative character of creativity. Within this theory, individual creativity is sometimes described as outdated.

There are however contradictory results as to whether collaboration in science is at all beneficial for creativity. The results vary also with the approach taken. Gorman, Gorman, Latta, and Cunningham (1984) found with experimental methods that interacting scientists did as well on tests as the best individual of the group. Taggar (2002) found that a group with high-creativity team members depended on having high “team creativity-relevant processes”. If this was not the case, the effect of the high-creativity members was neutralized.

From a socio-cultural approach, collaboration is by definition beneficial because creative achievements are seen as collaborative by nature. Within this approach, interactions of students are often analyzed. Miell and Littleton (2004) describe, for example, how collaboration enhances identity development through interpersonal connection, reflection, flexibility and motivation.

Again highlighting the possible disadvantages of collaboration, challenges have been researched in terms of personality clashes (Nolan, 1978), competition (Johnson & Johnson, 1989) and control issues (Pritzker & Runco, 1997). Feist (2006) comments that it is important that labor is divided amongst individuals with different skills. Sawyer, who views creativity as predominantly collaborative, nevertheless states (2012, p. 210): “creativity doesn’t exist without the individual”. According to Glaveanu (2014, p. 27): “…the cultural psychological approach is only one among other valid approaches to creativity and our task is to consider how to put these perspectives into dialogue”. Clearly, an integration of the individual and socio-cultural approaches is needed.

The focus on individual personality in this study confirmed earlier findings that creative scientists exhibit openness. This personality trait can be seen as positive for collaborative learning.

Interestingly however, some of the typical personality traits found in creative scientists do not seem the most suited for collaborative study or work. For example, disagreeableness, also found in this study as significantly related to creativity, means that very creative individuals are sometimes unfriendly, suspicious, skeptical, and more likely to compete than to cooperate.

According to Feist (2006) creative scientists are also rather dominant and Eysenck (1993, 1995) cites psychoticism as another personality trait. Batey and Furnham (2006) find creative scientists to be – amongst other traits – independent. The creative scientist seems made to work naturally on their own according to these findings. This is sometimes confirmed by quotes from eminent creative personalities. Physicist Albert Einstein (as cited in Calaprice, 2011) for example said that “the monotony and solitude of a quiet life stimulates the creative mind.” However, scientists are also sometimes known to collaborate closely. Research by McDonalds, Miell and Morgan (2000) maybe clarifies this. They found that friends working together create better results than non-friends. So working together with friends might be even more important for creative scientists to overcome personality difficulties.

Another issue for which this study adds to our knowledge concerns teaching. Research shows that although teachers state that they value creative students (Feldhusen & Treffinger, 1975), in reality teach-
ers sometimes discourage or show that they dislike students who display creative characteristics such as originality and desire for novelty (Cropley, 2001). Objective information about creative students might enhance understanding and acceptance of students by teachers. Teachers are empowered to make more knowledge-based decisions concerning creative work in classrooms.

Hennessey (2015) stresses the importance of intrinsic motivation in education. From a sociocultural perspective also Miell and Littleton (2004) explain how intrinsic motivation is strengthened through collaboration. The importance of intrinsic motivation may guide us to where a change towards creative scientific education could be initiated. Students might themselves become informed and empowered concerning creative personalities. It might be that an understanding of creative personalities encourages a creative attitude. Especially for high creative students, self-knowledge and acceptance of their personalities might fuel individual intrinsic motivation for creative thinking, indirectly benefiting collaborative work, and vice versa. For example, knowing that to be open helps to be creative might foster this attitude in students.

In summary, the demand for cooperative and at the same time innovative skills for the 21st century might be unattainable if one considers that solitude is also needed for creativity. According to the findings of this study, very creative people should also favor individual time. Hence, individual as well as collaborative scientific creativity should become part of higher education.

REFERENCES


**Scientific Creativity in Psychology**


**KEY TERMS AND DEFINITIONS**

**Agreeableness:** “The quality of one’s interpersonal orientation along a continuum from compassion to antagonism in thoughts, feelings and actions” (Costa & McCrae, 1985, p. 2).

**Intelligence:** “The ability to achieve one’s goals in life, within one’s sociocultural context” (Sternberg, 2005, p. 189).

**Intrinsic Motivation:** “Intrinsic task motivation is passion: the motivation to undertake a task or solve a problem because it is interesting, involving, personally challenging, or satisfying – rather than undertaking it out of the extrinsic motivation arising from contracted-for rewards, surveillance, competition, evaluation, or requirements to do something in a certain way” (Amabile, 2012, p. 3).

**Openness:** Sensitivity towards fantasy, feelings, aesthetics, ideas, actions and values (McCrae, 1987).

**Scientific Creativity:** The capacity to have novel-original and useful-adaptive ideas in the domain of natural and social sciences (Feist, 1998).
Chapter 4
A Creativity and Innovation Course for Engineers

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ABSTRACT
In this chapter, the teaching methodologies and pedagogical styles adopted within the “Creativity and Innovation” course, offered at the University of Bologna in Italy are described. The main goal of the course is to give students both a theoretical foundation and a hands-on experience about meta-cognitive strategies for the control of the creative thinking process. The students were engaged in the selection of a focus area within the range promoted by a call for new start-ups, creating the playground for team-oriented sessions in which relevant information was collected, divergent modifiers were applied, ideas were generated, business models were sketched and assessed, and finally concluding the course with a team presentation of the generated ideas. The feedback received from the engineering students was very positive. While the ideational part of the class followed a learning-by-doing approach, this was preceded by a specific theoretical part, striking an effective balance between theory and practice.

INTRODUCTION: TEACHING CREATIVITY IN THE INFORMATION SOCIETY

Even though we live in the XXI century, we still have to bear the consequences of the bipartition of schools of thought that occurred as a result of the age of enlightenment, with the sharp separation between rationalism and romanticism. These intellectual movements represented two very different ways of shedding light onto the human mind, as anyone can agree; however, the human characteristics that they praise are not and should not be in contrast. All human beings need both rationality and emotion, and indeed a very careful balance of the two. But this dichotomy is unfortunately still in place, and

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works as an implicit theory for both laymen and scholars, such that prejudices divide people into two rather sharply distinct classes. Clearly, engineers are pre-mapped into the rationality container. This is the reason why a discussion of creativity in the domains of science, technology, and particularly in engineering might appear to require qualifying statements. The real paradox is that, if anyone today is asked the simple question: “What do you think represented the major innovation in the course of your lifetime?”, it can be taken as a certainty that nearly all of the answers will regard technology, its systems or its devices, with the Internet and the smartphone contending the first two positions. Clearly, new ideas in the engineering domain enjoy today the highest impact, and therefore this implicit theory is actually far from the reality which is lived everyday by the scientist and the engineer who takes seriously his/her mission to produce advancements in knowledge and inventive innovations to improve the life conditions and sustainability of the human species. Engineers must be creative.

In this Chapter, we describe a course on Creativity and Innovation offered to engineers at the University of Bologna, focusing on the adopted teaching methodologies and pedagogical styles. The course was held by Prof. Giovanni Emanuele Corazza, who is the founder of the Marconi Institute for Creativity (MIC), and who teaches several classes inside the Telecommunications Engineering curriculum. The Marconi Institute for Creativity, a joint initiative of the Fondazione Guglielmo Marconi and of the University of Bologna, was founded in 2011 with the purpose of establishing creative thinking as a science. Some of its inspiring elements came by extracting the principles underlying the work and experimentation approach by Guglielmo Marconi (a Bolognese by birth) and other great inventors, artists, philosophers, designers, etcetera, and then by positioning these principles within a theoretical framework which takes a domain-general view on creative thinking. The three pillars upon which MIC operates are those of scientific research, education activities, and support to the process of creativity and innovation, both in academic and in business contexts. The study of the concepts at the basis of the creative process are considered to be essential to form a new discipline, starting from the belief that creativity itself is no longer an option, but a true necessity for the education of students at any level, and in universities in particular. Within MIC courses, creativity is presented as related to the concept of discovery as well as to the process of invention, both contributing to the development of the Information Society: the world as we know it is permeated by Information and Communication Technologies (ICT), and by the consequent changes that they have imposed on our society (Corazza, Pedone & Vanelli Coralli, 2010), opening up unprecedented opportunities. Every human being who is connected to the Internet can interact with millions of others, and benefit from the largest distributed database ever existed, with access to documents, reports, patents and in general information about any discipline, in real-time. Even though data cannot be confused with knowledge (Reddy, 1979), the fact that information is now a commodity has remarkable consequences on our everyday and professional lives. The expertise related to professional know-how does not have the same value that it had in history, when the spreading of knowledge was limited in time and space. The static possession of knowledge is rapidly becoming insufficient as a distinctive element, if not augmented by the ability to generate new ideas, explore alternatives, and imagine future scenarios: the human being must now bring creativity into play. Only by generating original ideas and efficient solutions can we avoid becoming mere nodes of a massive network. Creativity becomes then fundamental for the dignity of human beings, and it may well be the most difficult ability that can be transferred to artificial forms of intelligence. Even though there are plenty of researchers working on algorithms for the endowment of machines with the ability to generate, we believe it would be dramatic for human beings to give up on this very peculiar characteristic of theirs. Starting from these considerations, we believe that creativity needs to be freed from any romantic myths and be taught as a scientific discipline, which
begins with a clear definition of the construct (Corazza, 2015; Rhodes, 1961; Runco & Jaeger, 2012), and that certainly relies on contributions from many disciplines (Corazza & Agnoli, 2015a; Corazza & Agnoli, 2015b), but that also has a specific dimension of uniqueness that makes it an autonomous subject of study. As well described by Runco (2004), creativity can be approached from multiple points of view, from biological and neuroscientific, to the cognitive, emotional and personality related aspects, all the way to the macroscopic social and cultural levels (Csikszentmihalyi, 1988). Each different perspective contributes with specific elements, that enhance the overall picture. Great importance must be given to the measurement of creativity (Agnoli, Corazza, Runco, & Bhattacharya, 2014) and experimentation (Agnoli, Franchin, Rubaltelli, & Corazza, 2015). In general, there is a need to put the emphasis on a theoretical but pragmatist approach to creativity, contemplating the modelling of the creative thinking process, with both descriptive and prescriptive ambitions, in order to lead to strategies and methods for practical application. In a culture of creativity and innovation, the value of ideas is not only related to their originality, but to the effective impact they produce on the world.

The “Creativity and Innovation” course was presented for the first time during the 2013/2014 academic year. The specific case we report in the next sections corresponds in particular to the experience of the academic year 2014/2015. In the concluding Section of this Chapter, we also discuss future evolutions of the course, in terms of development of supportive ICT tools and of new theoretical methodologies based on conceptual metaphors.

THE CONTEXT: COURSE FRAMEWORK AND AUDIENCE

The Creativity and Innovation course is part of the study plan for students enrolled in the first year of the “Communication networks, services and systems” curriculum, as a mandatory course in Telecommunications Engineering at the University of Bologna. We believe that this is the only Telecommunications curriculum in the world that foresees a Creativity and Innovation course as a mandatory discipline. The course is also open to other Master degrees students from the University of Bologna, as well as to Erasmus and Erasmus Mundus students. In fact, not only engineering students, but also design and psychology students chose to attend the course, making for a very beneficial multi-disciplinary environment. For the academic year 2014/2015, the course took place in the spring semester, from February to May 2015, for a total of 30 hours of lessons organized in 10 classes of 3 hours each. 39 students attended the course with a required participation in 70% of the classes, or more. The average age of the students was approximately 23 years, and there were 29 male and 10 female students. The preponderance of male students is quite normal in the engineering environment. An important feature to stress is that the course was held in English, and that the course had a multicultural environment, covering three continents: out of 39 students, 50% of them came from Asia (Iran, India, Kazakhstan), 40% from Europe (Italy, Spain, Germany, and Russia) and 10% from Africa (Nigeria, Cameroon, and Kenya). We can observe that the course started with favorable conditions for creative activity, since multilingualism has been shown to have a positive impact on creative potential (Kharkhurin, 2012). Even though students may not be fully aware of the big picture presented in the previous Section, they nonetheless give greater and greater attention to the subjects of creativity and innovation, mainly because they are interested in acquiring soft skills for job interviews; still, they approach these subjects as being quite enigmatic. However, there is an entire literature on the subject, especially related to teaching scientific reasoning styles within the active paradigms of thought (Dow & Mayer, 2004; Dunbar, 1995; Hodson, 1986; Kuhn, 1962/2012;
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McComas, 1998; Medawar, 1991; Poincarè, 1952; Popper, 1963). Clearly, the literature related to the teaching of creativity for engineers and scientists is much narrower, and this Chapter aims at starting to partially fill this gap.

THE STRUCTURE: FOCUS AND TEACHING METHODOLOGIES

The course focuses on creativity as applied to innovation, with emphasis of the application examples devoted to the development of start-up companies. The course can be divided in two parts: the first representing historical background and theoretical aspects; the second exploring practical exercises to test the application of strategies and methodologies for creative thinking. The teaching methodologies include frontal lectures with active students participation for the theoretical part, and individual/team hands-on sessions for the second part. The theoretical part is to be seen as the preparatory platform for the practical application and use of the proposed model (Corazza & Agnoli, 2013) for the creative thinking process at cognitive level, identified as DIMAI (Drive, Information, Movement, Assessment, Implementation), with the specific purpose of guiding students to collaborate with colleagues in creating a new startup and the related product idea. The second part represents a challenging and innovative element for a university curriculum in engineering, with the hands-on experience of application of the DIMAI model to generate and develop business ideas in teams. Another task for the students is a public presentation of the resulting product idea at the end of the course. Students were required to present to an audience of virtual business angels their in-embryo start-up proposals, in a market field related to information and communication technologies (ICT). The jury of experts included MIC staff members and a representative of a start-up accelerator in Bologna.

In the following sections, we describe the structure of the course in greater detail.

THE THEORETICAL PART OF THE COURSE

Introducing Creativity as a Necessity for Engineers (and Beyond)

As one might expect, the first class was dedicated to the introduction of the objectives of the course, concerning the scientific approach to creative thinking, the use of systematic methods for idea generation, the necessity for the generation of new ideas for products and processes, and the development of new ideas for start-up companies, with a reference to the interaction with a start-up accelerator in Bologna. The class started from basic concepts, with the presentation and general explanation of creativity and innovation constructs, stressing the importance of creative thinking in human experiences, as a necessity to create new value through original concepts and new ideas, revealing creativity as our most precious resource. This general introduction is needed to attempt to dismantle the myths related to creativity, with particular reference to the implicit idea that engineers are not creative, as also discussed in the introduction to this Chapter, in an effort to stimulate the students self-esteem and interest. In fact, one of the largest hurdles to be overcome in the teaching of creativity is that of an insufficient self-esteem: students never feel they are entitled to be the next “great inventor”. In an effort to demonstrate that the topics addressed in the class are cross-disciplinary in nature, students are shown how creativity can be
applied to all domains, with different nuances, by identifying common principles. Clearly, it is at the same time important to show that there are domain specific elements, since being creative in engineering is different from being creative in the arts. During this class, general notions about business models and the business model canvas (Osterwalder, Pigneur, & Clark, 2010) were also introduced, so that the students can start immediately to think about ideas that have a real and exploitable impact on the external world.

This first introductory class ended with the presentation of the international CREAM project involving MIC and University of Bologna as partners of the project consortium, to engage the students in participating to the creativity measurement activities foreseen within the project. To briefly describe the project, CREAM (CREativity Enhancement through Advanced brain Mapping and stimulation) is a European Commission 7th Framework Programme project, that focuses on the multidisciplinary study of the neural substrates of creativity in different knowledge domains. The project joins cognitive psychology, to provide reliable and standardized measurements of creativity; neuroscience, to disclose the neural network underlying creative cognition; ICT, for the use of signal processing techniques to monitor the creative cognitive states in real-time, as well as to use brain stimulation instrumentation to establish a causal link between brain and body states with creative cognition. MIC is responsible for the measurement of creative thinking over large populations of students, using a purposely-developed test battery, addressing both convergent and divergent cognitive tasks. The CREAM test battery was used to explore creative performance in both artistic and the scientific contexts, in order to establish a correspondence between creative achievement and specific abilities, in a standardized multi-measure environment. During the first part of the creativity and innovation course the CREAM test battery was administered to the students, as part of the CREAM measurement campaign. The introduction and explanation of the battery tests, was instrumental for introducing students to what a “scientific approach to creativity” really means, making them feel as being part of a European project, and giving “authority” to the subject. The involvement of students in the CREAM test campaign can also be considered for its educational purpose of preparing them to the use of concepts related to convergent and divergent thinking. Twenty-nine out of the thirty-nine students participated in the test, which can be considered to be a good share, given that the participation to the test was not mandatory (test administration was purposely placed outside the regular class timetable). A preliminary analysis on the test results from 155 students evidenced in particular that the creative process can be considered to be a complex and dynamic ensemble of cognitive, motivational, attitudinal, and environmental components (Agnoli, Corazza, Cagnone, & Runco, 2015). This analysis specifically aimed at answering the pressing question about whether these components could assume different relevance in defining creative achievement in diversified domains (in our case, in scientific and artistic domains). Adopting a structural equation modeling (SEM) approach, we were able to justify a unitary creative thinking model that finds the proper place for both convergent and divergent thinking. We proved in particular that convergent thinking is essentially defined by problem solving abilities and highly influenced by cognitive abilities, as measured by an intelligence test, resulting to be the main determinant of scientific creative achievement. On the other hand, divergent thinking is defined by fluency and originality in producing alternatives, and highly influenced by personality, resulting to be the main determinant of artistic creative achievement.

**Historical Notes**

During subsequent classes we presented examples of well-known creative personalities through their biographical notes and the methods they used, for the purpose of extracting principles from their creative
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approach. The choice of the personalities was based on a historical review of major thinkers coming from different disciplines, who can be described as individuals who contributed to the definition of creativity with innovative ideas, works, or methodologies. The class started with a section dedicated to philosophers, and in particular to Heraclitus, with a selection of his inspiring epigrams. The discussion then passed on to great navigators, stressing their motivation, curiosity and preference for novelty, risk-taking attitude, and ability to find financial support from European monarchs. The artists’ section featured Vincent van Gogh and Paul Cezanne, focus on their guiding principles and methods, such as Cezanne’s emphasis on visual perception mechanisms, and van Gogh’s self-discipline and never-ending refinement of ideas. A similar approach was applied to the presentation of famous scientists: Charles Darwin, Marie Curie, Albert Einstein were creative personalities who used methods and principles that can be identified and developed, such as the visual thinking techniques of Einstein, or the “discovery by observation” approach by Marie Curie. Coming to the world of designers, the Memphis Group was introduced, focusing on their attempt to go beyond what they perceived as the limitations of the minimalism movement. Clearly, the more stressed section was that of inventors, featuring Leonardo da Vinci, Wilbur and Orville Wright, Claude Berrou, Vint Cerf, and Guglielmo Marconi. The latter, eminent personality from Bologna, was able to seize the opportunity and believe in his intuitions, notwithstanding the resistance and irony he faced, representing an example of a visionary inventor who always fascinated students, and engineers in particular.

**Homework: Writing an Article about a Successful Start-Up**

During the first class, students were asked to produce an article of approximately 2000 words about a successful start-up, in three weeks. The homework was assigned as a preparatory work to let students start thinking and reasoning about what really defines an effective start-up. The homework was aimed at going beyond the simple collection of notes from websites: students had to extract principles and ideas, focusing both on the process that led the start-up to being successful and on the product or service that it offers to its customers, with a reference to the value proposition and the customer segments, according to the business canvas approach (Osterwalder, Pigneur, & Clark, 2010). In order to give a reward and stimulate the students, we announced the publication of the best article on the MIC website at the end of the course. Among the articles we received, some of them were particularly interesting, showing the students keen interest in deepening the reason behind the success of start-up companies. Here we report a citation from the best article:

*So the lesson I learned with (name of the startup) is that aside from your product, the company is only as good as the people who work for it. Making sure you invest in your team is vital. One more lesson I have learned is that the expansion of a product is not easy, and we have to adapt our team and product for every city, every social group, for making it successful and useful for that new sector. So if that team, working that way, reached the 500,000 global downloads within one year, and still they have a lot of things to come (by seeing the potential of their idea and also his team), what can we bring to the world with one good idea and the will to work hard for it?*
The course went on with the intervention by Simone Ferriani, Professor of the Department of Management of the University of Bologna, who was invited to talk about social networks and creativity, to present to students a different perspective on the process of idea generation. Ferriani's presentation focused on how conventional wisdom about creativity, which perceives the creative person as a "lone genius having a solitary insight", should be reviewed by historical evidence, such as that given by the large team of collaborators of Thomas Alva Edison at Menlo Park. Creativity can therefore be seen as a social process, and the consequence and direct result of a social system of actors that amplify or stifle one another’s creativity. His intervention, combined with the dismantling of myths related to creativity during the introductory class, stressed again how each human being can be creative and enhance his/her creativity potential, along with the importance of team work, an essential concept for the second part of the course.

As far as the theoretical approaches to creativity are concerned, the course focused on neurological aspects, cognitive approaches, personality-social approaches, confluence models and the DIMAI model. Starting from an overview of the neurological basis for creativity, students were informed of the fact that this research field is yet in its beginning, with a struggle to go beyond the fact that the approaches are not perfectly coherent with reference to methodology (EEG vs. fMRI), to the creative process “under analysis” (insight vs. divergent thinking), to the multiple application domains (e.g., artistic creativity, scientific creativity, engineering creativity, etc.), along with the complexity intrinsically permeating the creative thinking process. This was followed by a review of brain areas that are activated during the generation of new ideas (Benedek et al., 2014), and about the crucial role of subcortical areas as Nucleus Accumbens (NAc) during the phenomenon of insight (Floresco, Blaha, Yang, & Phillips, 2001; Haber & McFarland, 1999; Tik, Sladky, Di Bernardi Luft, Hoffmann, Hummer, Banissy, Bhattacharya, & Windischberger, 2015). This discussion gives evidence of how creativity is a fascinating and open issue to be investigated. Moving on to cognitive approaches, we presented the fundamental theoretical modeling notions for the creative process: the four-stages model by Wallas (1926), the articulation of the mental abilities by Guilford (1950), the eight dynamic stages with the elimination of all non-conscious elements from the model by Mumford et al. (1991), the Geneplore model (Finke, Ward, & Smith, 1992). As far as personality-social approaches are concerned, the lesson focused on motivation, and the related distinction between extrinsic and intrinsic elements (Hennessey & Amabile, 2010), along with a reference to personality traits and the measurement of individual differences through precise factors (Digman, 1990; Goldberg, 1990; McCrae & Costa, 1997). This information supported the introduction of an experimental investigation on the relationship between the Openness personality trait and creativity (Agnoli, Franchin, Rubaltelli, & Corazza, 2015). Regarding the socio-cultural approach, the interest was centered on explaining the roles of the individual thinker, the field of experts, and the knowledge domain, describing the creative phenomenon from a systemic point of view (Csikszentmihalyi, 1988; Nakamura & Csikszentmihalyi, 2001). Investment theory (Sternberg & Lubart, 1996) was then explained, drawing an analogy from the finance domain, defining creativity as a decision that anyone can take but that few people actually make because of the related risks, i.e. the cost of being original could be too high. This theory defines creativity as the cooperation of several components such as individual intellectual skills, knowledge, thinking styles, personality, motivation, and environment, with possible mutual compensation and thresholding mechanisms.
All this information represents the prelude to the DIMAI model presentation, where DIMAI represents a theoretical model that encompasses all the previously mentioned cognitive approaches (Corazza & Agnoli, 2013). The DIMAI model represents a functional description of the creative thinking process that can be applied to any knowledge domain. The formulation of the model encompasses the cognitive, motivational, and attitudinal components of the creative process, considering the social and environmental elements that influence the factors interacting in the process. The DIMAI model is composed by five mental states (Drive, Information, Movement, Assessment, Implementation) interfaced by selection gates. Two thinking modalities are contemplated in the model: the convergent and the divergent modality. The former modality can be described as the inclination of the mind to select a single pattern as the representation of “the right solution or best answer” given a set of input information, while the latter is the disposition towards looking for all possible alternative solutions, with an exploratory attitude. The DIMAI mental states should not be intended exclusively in their sequential order, since they can coexist in parallel and be reiterated. Specific thinking components can be used above or below the level of awareness. Let us now describe the five mental states in some detail.

The Drive state involves the selection of a main focus area of interest, in which the generation of ideas shall take place, taking into consideration the emotional elements that support the thinker throughout the entire process. In fact, the focus area should be linked to the motivation of the thinker to put effort and cognitive energy to generate new ideas in the selected area. Using specific analytical tools that allow considering several aspects of the selected general subject or topic, the thinker obtains a refined focus area. The state that follows is that of Information, that consists in gathering knowledge elements related to the refined focus area. Knowledge elements include meaning, symbology, and/or the physical realization of items related to the focus area. Clearly, the more the thinker has previous knowledge and/or expertise in the selected focus area, the richer the collection of information will be. This kind of information is identified as relevant, to stress the “semantically direct” connection to the focus. Along with relevant information, the DIMAI model includes the introduction of irrelevant information as well. This information has no apparent relation with the focus area, but it can find an a-posteriori justification. It represents a spark, a possible inspiration, forcing the thinker to accommodate this extraneous or peripheral element, and consequently re-organizing the knowledge structure, which leads to the possible generation of new perspectives. The methods for introducing irrelevant information are several: the transformation of relevant information items through the application of divergent modifiers is the main route, but irrelevant information can also come from the environment surrounding the thinker, or from a distant knowledge area (cross-pollination), or even from random causes. At the output of the Information state, due to the introduction of irrelevant information the thinker selects a Platform, represented by a statement lacking a priori justification, which will lead him/her to the next state, Movement. The name of this state is inspired by the mind free interconnection from one idea to the next, without a priori judgement, exploring the complex network of alternatives, through interpretation, inquiry, insight, and so on. Movement as well can be convergent or divergent, depending on the adopted thinking method: it can be the search for the best possible consequence by induction or induction, or a deliberate exploration for alternatives. The outcomes of movement are a number of potentially novel ideas, which can now be judged. Ideation is therefore followed by the Assessment state, which can take on a convergent modality, according to which the thinker assesses the value of the novel idea with reference to the initial focus, or a divergent modality, where the resulting idea is judged independently from the initial target, enabling serendipity. At the end of the journey, once the thinker is satisfied with an idea, a Plan to convert the idea into a real product can be organized, representing the final state of Implementation.
In the following, we explain how the DIMAI model was used for teaching purposes.

THE TRAINING PART OF THE COURSE

Drive and Focus Area: The Teams

As mentioned before, we associated the learning of idea generation concepts and methodologies to a call for innovative companies presented by a start-up accelerator staff during the first classes. This accelerator launches the initiative every year, and grants support to business ideas in fields related to digital technologies, such as mobile communications, smart city, smart home, automotive, gaming, health & wellness, data analytics, green solutions, social impact, social networking and wearable devices. The students were therefore engaged in the selection of a preferred focus area within the range promoted by the call. This was done by using specific methodologies taught during the course and aimed at guiding the attentive and motivational resources (i.e. the creative Drive) among many alternative routes, allowing for example to score the different focus areas according to the criteria of urgency, necessity, usefulness, attractiveness, and confidence. The individual preferences were collected in real time so that students joined groups with colleagues interested in the same focus area, avoiding the typical situation in which students create work team based on friendships and acquaintances.

The creation of teams (from 5 to 7 students per group) represents the starting point for team-oriented sessions to explore the use of the DIMAI model. Each group selected a team leader, who was in charge of organizing the teamwork material, representing the contact between the team and the professor. Once the focus areas was defined, students were asked to work with their teams separately, facing dedicated sessions where, state-by-state, the different components of the DIMAI creative thinking process were elicited under the guidance of the professor and MIC staff.

Information: Collecting Material about a Refined Focus Area

The team sessions began with a first meeting of each group with the MIC staff. Starting from the general focus area identified by each team, the teams began to redefine it by choosing a maximum of three refined focus areas out of the general area, working with methodologies aimed at disassembling the general area and selecting refined areas, according to the interest of the team as a whole. After the session, students were given a specific homework: starting from their refined focus, the team had to collect relevant information items to be presented during the following session.

Movement: Introduction of Divergent Modifiers and Idea Generation

During this session, students worked with systematic idea generation, which represented their first experience on the disciplined introduction and use of irrelevant information and on the management of divergent movement techniques. This is the moment in time in which students have to face the most challenging part of the creative path: the interpretation of irrelevant information and the consequent opening of new perspectives, that finally lead to the generation of an innovative idea. Indeed, the modification of the relevant information related to the focus area through the use of divergent modifiers has the power of parachuting the student’s mind into a previously unknown state, passing from being inside the Com-
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mon Knowledge Domain (CKD) to a state identified as Out of the Common Knowledge Domain (OO-CKD). The difficulty is to proceed without any anticipatory judgement of the outcomes: students shall inhibit the instinctive reaction to reject their own ideas. Indeed, students are encouraged to start from the platform resulting from the modification of relevant information and move on using metaphors and analogies. This method stimulates the capacity of the brain to open new paths and exploit imagination, returning back to the CKD with original ideas.

After this session, each team received a report summarizing the ideas generated through the application of divergent modifiers. The homework for the following session was to select the idea(s) that they believed had the highest potential for successful realization. Students were free to refine, merge, evolve the ideas from the map, but always keeping a clear reference to the initial point of departure, so that the ideational activity could be traced back to the process. If students generated other concepts outside of the guided idea generating session, they were suggested to merge them into the idea selected from the report, always striving for coherence and soundness from a business point of view. This work of refinement had to result in a one-page description of the business idea, including the final product, which represented their value proposition, and could optionally contain additional elements of the business model. The following session represented the last meeting before the final presentation, dedicated to the Assessment and refinement of the idea.

Assessment of the Idea

The Assessment of the idea (or cluster of ideas), resulting from the refinement after the Movement session, was based on the use of a set of assessment tools, allowing for example to consider the positive aspects of the proposed idea, its interesting elements, the negative elements, and the solutions to overcome them and make the idea more robust. The students actively participated in the estimation of the idea as a team, evaluating it with reference to the current market and ICT environment, in which they could hypothetically launch their product idea.

Implementation: Idea Presentation as a Final Exam

As mentioned in the introductory section, the Creativity and Innovation teams had to present their product idea during the last class of the course. Each team had 20 minutes for the presentation, which had to include as a minimum the general description of the idea, the name and logo of the product idea, the process of idea generation (how they obtained the idea), the evaluative elements, and business model elements. Teams presented their idea in front of a jury of three experts and an audience (their course colleagues), who acted as potential venture capitalists for the proposed business ideas. The jury was composed by one representative of the start-up accelerator and two representatives of a multimedia innovation company working in the field of ICT solutions and applications, operating in the Bologna area. In the following we provide a brief description of each product idea generated by the six teams (SH4LP, AURA, Telecom Team, Nerd Team, NMR4S, and WelCom), as the result of the creativity journey they undertook, referring to their presentation.

The first product is the result of the creative process of the SH4LP team, which focused on Smart Homes. The initial work dedicated to the analysis of the general focus area revealed that the team was oriented to two specific refined areas: energy saving and event monitoring. The relevant information extracted during the Information state concerned the reduction of pollution in the energy saving refined
focus, while for event monitoring the students considered the risk for privacy to be violated. Platforms resulted from the application of divergent modifiers, and Movement led the team to generate the concept of “automatic shades”, and the consequent generation of their idea: 3S (Smart Solar Shades). 3S are smart shades integrated with photovoltaic panels that are able to regulate the incoming light in a house on the basis of presence of persons inside rooms. The product idea considered also a smartphone app to handle the system as a remote-control.

The final assessment further refined interesting aspects, proposing for example different versions of the ideas with adhesive photovoltaic panels, to reduce the initial high cost. This can be considered as a positive teamwork result, since the students of the group were stimulated to produce new ideas to overcome problems arising from the features of the main idea.

The AURA team and related product idea resulted from choosing “Green Solutions” as their general focus area. The redefined focus area was about renewable products, selecting in particular the relevant information: “fuels can be produced with waste”. The platform enabling movement was realized by exploiting the concept of the “tunnel effect”, which led the team to metaphorical move from the statement “chemical reaction can try to mimic tunnel effect”. The development of the concept guided the team members to assumptions concerning chemical reactions happening with less energy than normally requested, keeping temperature low, reducing cost for extracting energy, all the way to the “cold fusion of waste”. The teamwork came on to considering rust as a coating mechanism, and the resulting product idea was about a new coating process for telecommunication cables, based on the chemical and structural properties of iron-oxide. The presentation captivated the jury especially for its product placement analysis.

The focus area of the Telecom Team was that of Mobile communications, and the generated product idea concerned a smartphone application named CONROAD (comfort connecting with safety on the road). In the Information state, the refined focus area of wearable devices was considered in particular, from which Movement led the team members to make an association with smart phone applications. Considerations about wireless sensors moved the team to road safety applications. Through the Assessment state the idea was refined to result in CONROAD, a new smartphone application for car transport, to aid the driver in case of emergencies abroad, and for signaling the presence of danger on the street; an application that should always run in the background, when activated. This road safety application could also be used for automatic car crash detection warning, with notifications among mobile phones with activated GPS. Finally, the team proposed to consider two customer segments: car drivers and cyclists.

The NTC (Nerd Team Console) was the product idea by the Nerd Team. Clearly, the focus area was that of advanced Gaming. The Nerd Team members chose this focus area since they believed it well represented the concepts of collaboration and coordination with others (multiplayer games). This idea was inspired by a environmental visual input: the team used to gather in the Faculty yard under a tree, which was in full bloom during spring and was bared during winter. Starting from this “irrelevant” information, they explored the metaphoric tree to obtain the basic and essential structure of a new console for both gaming and graphic design, based on the use of next generation virtual and immersive environments. The NTC idea was conceived in both software and hardware elements. The idea assessment led the team to try to rearrange the cost elements, guiding them to specific ideas related to partnerships and open source contributions. The team showed a keen interest, presenting also a tentative price for the simulation kit of the gaming console. From a marketing point of view, the jury found this idea interesting but not very innovative.

SelphONE is the name of the product generated by the NMR4S Team. The starting point of the Team was their interest in investigating new solutions for the area of mobile devices. Their refined focus area
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was about modular smartphones and their potential in future technology implementations. The team collected and elaborated information taking inspiration from current technologies, such as Google’s Project Ara. The piece of relevant information “Near field communication (NFC) can be used in proximity”, was modified with the use of an analogy with the biological concept of photosynthesis. The Movement led the team to conceive the concept of using photosynthesis to generate solar energy to charge battery. Since the team was attracted by new functionalities, they concentrate their thoughts on how to merge different modules to save energy, resulting in the idea related to design and production of innovative and personalized blocks, e.g., solar-powered or piezoelectric batteries, compass, special lens camera. During the Assessment state, the team underlined the necessity to further explore the modalities to capture CO₂, and to overcome problems linked to the low efficiency of technology for energy harvesting, developing for example partnerships with companies working in nanotechnology, using graphene. The team was particularly determined to invest time in this project, for the apparent current lack of competitors in the market for this target.

The name of the sixth team and product idea is WelCom. The team started from the focus area of Health and Wellness, with a refined focus on IMD (Implantable Medical Devices). The guided creative process led the team to the idea of a new generation of implantable bio-sensors, to be used as medical devices to monitor vital health functions and patients health conditions, with the ability to signal anomalies in real time also through mobile applications. The idea did not seem to entail significant improvements with respect to state-of-the-art technologies, except for a reference to a mobile application. In the case of this team, the creative process encountered some obstacles related to group dynamics: the members of the team were stuck in their generation and development of original ideas due to the attitude of the team leader. Throughout the group sessions, the leader had doubts over the possibility to have original ideas in this specific focus area, influencing the members who felt uncomfortable in expressing their own opinion, blocking new possible ideas with negative assessments such as “this already exists”. The leader fell into the trap of assessing the idea with excessive anticipation. Clearly, this approach to teamwork and in general to creativity makes it very difficult to arrive at the generation of valuable and novel ideas. Leadership is a very important element for creativity (Sternberg, Kaufman, & Pretz, 2003).

At the end of the presentations, the jury evaluated each product idea with scores (from 0 to 5) on the basis of their originality, feasibility, and attractiveness for venture capital, simulating the point of view of business angels. The scores for each category and related ranking were announced to students, and their reactions recorded.

CONCLUSION

It is not a simple matter to draw conclusions on a course that has been taught for only two years. The more proper approach would seem to be to learn the possible lessons and discuss the future. However, we are anyway in the position to address some facts that resulted from the performance of the engineering students in this course on Creativity and Innovation, which clearly has no simile in their curriculum of study. As far as the learning outcomes of the course are concerned, it can be stated that the course was a success. At the end of the classes the students gained sufficient to very good knowledge about the following topics: lessons from the history of science; theoretical foundations of creative thinking; cognitive modeling (including but not limited to the DIMAI model); and business model general concepts. Even though these can be considered only the basic elements for a thorough approach to creativity studies,
these are sufficient for a student to get a head start in a discipline that can be cultivated for the rest of one’s life. And, beyond the notional elements, the results of the Creativity and Innovation course have been particularly positive in terms of leading the engineering students to come out of the typical attitude of “learning a lesson well”: students were asked and trained to be open-minded and ready to perform activities with no single “right/wrong” answer, to foresee worlds of opportunities to be discovered and explored. Students took on an active role in focus selection, original ideas generation, and final presentation with active and enthusiastic participation, to the overall benefit of the class. Through the practical application of the taught methods and techniques in their areas of expertise, students were able to practically understand the impact of a disciplined approach to creative thinking. Indeed, the ability to systematically generate new ideas through a conscious process resulted, in the eyes of the students, to be an evident benefit for the invention of original products in their domain of interest.

What is for the future? Let’s discuss two directions for possible development of the class: the use of ICT tools for co-creation, and the systematization of the use of the metaphor as a cognitive tool for idea generation. Starting from the tools that can be offered by Information and Communications Technologies, it is clear that they can be instrumental in interconnecting students (and thinkers in general) to allow a joint elaboration of a focus area, for the generation of new ideas. Indeed, brains working in parallel can produce a dramatic thinking power that needs to be carefully controlled, as would be necessary for a powerful engine. This is the reason why a structured process, such as the one described and prescribed by the DIMAI model (Corazza & Agnoli, 2013) is necessary to conduct a controlled session with the wanted proficiency. A first experiment has been performed in another class, “Scienza e Applicazioni del Pensiero Creativo” (in Italian), for a curriculum in Industrial Product Design. On line forms were prepared for the drive, information, movement, and assessment states of the DIMAI model, and communicated to the students by email. While the students were working on the focus area of “Security for citizens”, real-time results became visible and projected on a screen. This served as immediate feedback and stimulus between participants. The quantitative results were amazing: 801 ideas were generate in the course of a single experiment (2 hours), attended by around 50 students. In planning to propose this kind of co-creation experience to the students of the Creativity and Innovation class, the ICT tools should be refined, as the present version still required intense human intervention in passing from one DIMAI state to the next. Also, we are planning to develop a smartphone application, with a dual modality of use: individual and collective. This kind of creativity companion would be very useful to note down ideas and processes as they occur in the course of a lifetime.

Coming now to a more theoretical development of the class, it should be noted that one of the most difficult parts of the DIMAI model is clearly the one related to movement, after the introduction of irrelevant information to exit the common knowledge domain, as described above. Now, it would be very beneficial for the students if systematic methodologies could be devised to help in this critical part of the process. For this, we are working on the concept of metaphors, which are more than just a linguistic device: they represent a fundamental mechanism for human thought (Cacciari & Glucksberg, 1994; Gibbs, 1996; Lakoff, 1990; Lakoff, 1993; Lakoff & Johnson, 1980; McGlone, 1996; Murphy, 1996; Ortony, 1979; Reddy, 1979; Tourangeau & Sternberg, 1982). Essentially, working with metaphors can be an excellent way to train the students to go beyond literal interpretations and move into the realm of figurative language, in which meanings are not ready to be grasped, but rather require divergent work in all possible directions. This is specifically true for novel metaphors, as the interpretation of conventional metaphors becomes more and more “stock”, up to the point where they can become idiomatic expressions. This is the typical evolution path of a metaphor or the “career of metaphor”, as Bowdle & Gentner
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(2005) put it. However, following the steps described by the DIMAI model, all of the metaphoric expressions one encounters are novel and require interpretation. As Gentner, Bowdle, Wolff, & Boronat (2001) observed, metaphor is like analogy, in the sense that it requires structural alignment and projection of inference from a source domain to a target, an activity which we now know is mainly performed by the right hemisphere (Benedek, Beaty, Jauk, Koschutnig, Fink, Silvia, & Neubauer, 2014; Faust & Mashal, 2007). And, in the course of the inference activity, previous knowledge about the target is re-organized: new ideas are generated (Kelly & Keil, 1987; Lakoff, 1993; Lakoff & Johnson, 1980; Tourangeau & Sternberg, 1982). We believe that an interdisciplinary approach to our Creativity and Innovation class based on psychology, linguistics, history of science, philosophy, engineering and technology, has the potential to provide the students with an exceptional asset with which the challenges posed by the future society can be faced (Brynjolfsson & McAfee, 2014; Corazza, Pedone & Vanelli-Coralli, 2010).

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KEY TERMS AND DEFINITIONS

Co-Creation: Collaborative generation of ideas that are original and effective, typically through the use of ICT tools.

Convergent Thinking Modality: Cognitive ability to converge from a set of encoded stimuli to a single pattern providing the best possible match.

Creativity: Activity of individual or groups related to the generation of products characterized by potential originality and effectiveness.

DIMAI: Cognitive model describing the creative thinking process, based on five mental states: Drive, Information, Movement, Assessment, Implementation.

Divergent Thinking Modality: Cognitive ability to explore alternative patterns starting from a single encoded stimulus.

Information Society: A form of societal organization which is characterized by the widespread use of Information and Communication Technologies, providing ubiquitous access to information databases.

Information and Communication Technologies (ICT): Technologies related to the exploitation of telecommunication networks and devices, computers, and electronics.

Innovation: Activity of individual or groups related to the practical exploitation and implementation of products and processes characterized by potential originality and effectiveness.

Pragmatist Approach: Methodology based on the posits and tenets of pragmatist philosophy, relating meaning to the impact on reality.

ENDNOTE

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Chapter 5
Teaching Creative Problem Solving in Engineering Education

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ABSTRACT
In this chapter, the principles of active learning and the contents of a creativity course entitled: Creativity and Problem Solving, are presented. The main purpose of this course was to create a space for discussing, reflecting and experimenting with creativity, creative processes and creative methods of relevance for university students working with problem-solving approaches. This course was developed at the Technical University of Denmark during the period 1998-2008 for engineering students of various specialities. It started with very few students and developed to a very popular course attracting many students from abroad. The selected themes, the methods and techniques, the structure of the course, the learning processes and the achieved results can be applied to a similar course for university students of other fields such as IT, Management Sciences, System Sciences, Computer Sciences, Design, Agriculture, Business, Art and Education, etc. Finally some reflections, recommendations, and conclusions are also presented.

INTRODUCTION
In recent years, creativity has been widely recognized as vital to success in the emerging global economy. An issue of PeerReview (Wince-Smith D. L., 2006), a publication of the Association of American Colleges and Universities, is entitled The Creativity Imperative and offers a collection of papers acknowledging the importance of creativity in building a competitive workforce and calling for education institutions to play a more active role in teaching creativity to students. In the last decades, many industrialised countries are shifting from an industrial economy to a knowledge economy, an economy based on the production and distribution of knowledge and information, rather than production and distribution of goods. In these economies, knowledge workers are “symbolic analysts” who manipulate symbols rather than machines, and who create conceptual artefacts rather than physical objects. Then the importance of
creativity, innovation, and ingenuity is central to the knowledge economy. If the core of the knowledge society is creativity, then the key task for educators is to prepare learners to be capable of participating creatively in an innovation economy (OECD, 2015).

Individual creativity is ubiquitous. New technologies both enable and urge fresh approaches to creativity in the context of education. University-level education offers a natural place to adjust pedagogical structures in favor of an approach to learning that organizes the intellectual community into new patterns of interaction and time allocation. This direction is made possible by the vast improvements in access to information, data, knowledge, and opinion. University students live in this world of access, in an ever-expanding sea of material. Networking second-by-second is central to their zeitgeist. The result is far more than social. Interaction and collaboration are now important in most workplaces, and are expected to be even more important in the future. Higher education needs to use its natural resources in the ways that develop content knowledge and skills in a culture infused at new levels by investigation, cooperation, connection, integration, and synthesis. Creativity is necessary to accomplish this goal. When central and culturally pervasive, creativity becomes exemplified and enhanced for every student. As a technique that can be advanced through practice, problem solving becomes a driving pedagogy in developing creativity in higher education (Vidal, 2009). Universities must meet the challenge of reapportioning time if suggested changes are to occur. The format of classroom lecture is by nature, not a natural laboratory for interaction and collaboration. Making the curriculum about interpersonal exchange opens the experience for every student to express, share, and test his or her creative instincts. Exchange turns the historical paradigm around and makes the presence of other students and faculty the core attribute of the curriculum and the scheduled classes value added.

The seminal book, *A Whole New Mind* (Pink, 2005), the author makes the point that in the twenty-first-century workplace, collaborative thinking and interacting will be increasingly core. Although jobs will change, diverge, and morph, employers are more and more going to seek workers who are adept at teamwork and capable of contributing original thoughts to group assignments and tasks. As the university’s purpose lies beyond mere career preparation, it is also incumbent on the academy to validate the college diploma as relevant to the future of its graduates. Therefore, the curricula must be intentionally formed around courses, projects, and seminars in which both collaboration and creativity work in consort.

However, today’s educational centres often fail to meet this need. These centres teach students that knowledge is static and complete; the students then become experts at consuming knowledge rather than to create knowledge. The above-mentioned development means that professionals as problem solvers are facing new demands: *skills and abilities of creative problem solving in collaboration with a group of stakeholders (actors, participants, clients and users) related to technological based problematic situations or messes.* Therefore, it is important to teach students specialisation methods and techniques to support and facilitate creative and participative problem solving processes. These creative approaches will complement the traditional understanding of problem solving as a highly rational and programmed process. In addition, problem solvers working creatively and facilitating creative processes experience a constant contact with the pleasure of creation; their work sometimes becomes artistic activities (Vidal, 2004). This will contribute to having a good and enjoyable life. Creative thinking can also become a life style, a personality trait, a way of regarding the world, a way of interacting with others, a way of working in groups, and a way of living and growing. Living creatively means developing one’s talents, tapping one’s unused potentials and becoming what one person is capable of becoming through interaction with other people.
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The main purpose of this chapter is to reflect and communicate about our experiences and practices from teaching a creativity course for engineers entitled: Creativity and Problem Solving, which can be transferred to other fields in higher education (e.g. IT, Management Sciences, System Sciences, Computer Sciences, Design, Agriculture, Business, Art, and Education, etc.), where problem solving is a central activity. The course had been running from 1998 to 2008 at The Technical University of Denmark. The course evolved every year, and after five years it took its final shape. Although some practical experiences have been presented in previous work where most of the empirical and factual practices related to engineering have been reported (Vidal, 2007 and Vidal, 2010), this chapter will discuss at a meta-level the principles, the design and the organization of a course in order to create a space for students when they discuss, reflect and experiment with creative processes and creative methods in facing problems to be solved in an innovative and collaborative way. We believe that this reflective, active and experimental approach will indirectly influence the development of students own creativity. In this respect, the focus will be centred on the role of the problem solver as supporter or facilitator of problem solving groups. Accordingly, a textbook has been developed for this course entitled Creative and Participative Problem Solving - The Art and the Science, which can be seen in (Vidal, 2006a).

The next section, Creativity, will present shortly our interdisciplinary and holistic conceptualization of creativity and creative processes to be applied in problem solving. This interdisciplinary approach is one of the main principles of the course. In the section Learning, the learning principles used in this creativity course will be outlined. Next, the section Design and Organization will present in detail how the course was designed and organized. The different stages and corresponding learning styles of the course are described. Then, the following section will present the evaluation and reflections of this teaching experience both from the student’s and the teacher’s viewpoints. Finally, the last section presents the final remarks.

CREATIVITY

The main point of departure is the work of the father of modern creativity: E. Paul Torrance (Millar, 1997). He was a pioneer in creativity research and education for more than 50 years. Torrance saw creativity as a process and has developed a battery of tests of creative thinking abilities. He believed that all individuals are creative and that creativity can be enhanced or blocked in many ways. He considered creativity developmentally, opposite to those who believe that a person’s creativity was established at an early age; however, his research has shown that creativity does not develop linearly and that it is possible to use activities, teaching methods, motivation and procedures to produce growth, even in ageing. Torrance asserts that creativity is an infinite phenomenon, one person can be creative in an endless manner and that a central element in developing his (her) creativity is practice. The person may find creativity in many apparently different areas: humour (ha-ha), science (aha) and art (ah). So Torrance’s experience and research have increasingly made him aware of the dreadful importance of falling in love with “something” – a dream, an image of the future. He was convinced that the driving force and motivation behind future accomplishments was the image of the future of people. Positive images of the future are a powerful and magnetic force. These images of the future draw us on and energize us. Giving us the courage and will to take important initiatives and move forward to new solutions and achievements. To dream and to plan, to be curious about the future and to wonder how much it can be influenced by our efforts are important aspects of our being human. In fact, life’s most energizing and exciting moments
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occur in those split seconds when our struggling and searching are suddenly transformed into the dazzling aura of the profoundly new, an image of the future.

Although it is difficult to give a simple and general definition of creativity, it is easier if we restrain to study creativity in relation to problem solving tasks. Herrmann (1996) gives a short definition that encapsulates many other definitions presented in the literature: What is creativity? Among other things, it is the ability to challenge assumptions, recognize patterns, see in new ways, make connections, take risks, and seize upon chance. Let us elaborate a little more on this definition: challenge assumptions means questioning the basis of the problem formulation with the purpose of problem reformulation; recognize patterns means that usually chaos and complexity are caused by simple patterns which, when recognised, lead us to the solution to the problem; see in new ways means looking for patterns from different perspectives: a rational or logical, an organisational or procedural, an interpersonal or emotional, an intuitive or imaginative, and an experimental or holistic; make connections, or bisassociate, means that many creative ideas are the result of synergy occurring between two thoughts or perceptions of usually very different areas (metaphors); take risks means there always exists the probability that one’s ideas will lead to failure due to many factors out of the control; and seize upon a chance (serendipity) means to take a calculated risk in order to take advantage of an opening that will allow to move forward toward a creative solution.

The Creative Person

At least three types of creative persons can be identified. First, the problem solver where the person (subject) is trying to solve a problem (object) in a creative way, which can be the case of engineers, doctors, managers, scientists, advisers, etc. Secondly, the artistic person (subject) who creates a new piece of art (object) will usually be in close interaction with the object. The “soul of the artist” will be in the object, which can be a product (e.g. painting, music, and film, etc.) or a process (e.g. dance, theatre, and performance, etc.). And thirdly, the persons who adopt creativity as a lifestyle being creative at work, at home and everywhere, both in an extrovert and introvert way (e.g. inventors, artists, and fashion designers, etc.).

Miller (1989) has developed a questionnaire that helps persons to identify their styles of creativity. It is founded in three assumptions:

- Each person has the ability to think creatively in different ways, the main issue is: how is he or she creative?
- Each person has equal potential for creativity, but persons have different approaches to making change when they work, and
- There is not a single style, but a combination of styles, yet still each person has a favourite style.

A person’s creativity style is founded in how he/she uses information to stimulate his/her creativity. Each creativity style prefers a different method for generating and evaluating ideas. Miller’s research (1989) shows that preferences for style can be classified in four categories:

- The modifying style likes to ask: what can we adopt to improve upon what had worked before? These people are more comfortable working with facts and making decisions. They seek solutions using methods that have worked before. They are precise, reliable, efficient and disciplined.
The visioning style likes to ask: what can we realistically image as the ideal solution over the long term? These people trust in their intuition and like to make decisions. They seek for solutions that focus on maximising potential. They are persistent, determined, hard working and visionary.

The experimenting style likes to ask: what ideas can we combine and test? These people emphasise fact-finding and information gathering. They seek for solutions by applying pre-established processes and experimental trial and error. They are curious, practical, and good team players.

The exploring style likes to ask: what metaphors can we use to challenge our assumptions? These people like using their insights to guide them. They collect lots of information hoping that it will help to approach problems from different angles. They are adventurous, dislike routine, and like to be challenged.

Amabile (1983) has documented that creativity in each individual has three components:

- Expertise,
- Creative-thinking skills, and
- Motivation.

Expertise is in a few words knowledge in its many forms: technical, procedural and intellectual. Knowledge can be acquired both theoretically and practically. Learning how to learn is an important tool for becoming an expert in modern Society. Creative-thinking skills determine how flexibly and imaginatively people approach problems and tasks. It demands courage to be creative because you will be changing the status quo. According to Amabile (1983), individuals can learn to be more creative and can learn to use creative tools in problem solving. Motivation is the last component. An inner passion and desire to solve the problem at hand will lead to solutions far more creative than external rewards, such as money. This component, usually called intrinsic motivation, is the one that can most immediately be influenced by the work environment. Amabile’s research (1983) has identified six general categories that support creativity: challenge, freedom, resources, work-group features, supervisory encouragement, and organisational support.

Amabile (1998), after many years of research focusing on creativity within organisations has also concluded that individual creativity gets killed much more often than gets supported. Mostly, it is not because management has a vendetta against creativity, it is undermined unintentionally because of the optimisation of short business imperatives: co-ordination, productivity, efficiency and control. Her research has shown that it is possible to develop organisations where both profit and creativity flourish, but the organisation managers need a conscious strategy. Torrance’s research (Millar, 1997) has also shown that children’s creativity gets killed in the primary schools and it is possible to design schools and education systems where both rational and creative work flourishes. Amabile (1998) has drawn attention to the crucial importance of intrinsic motivation in creative endeavour. Business has traditionally rewarded people extrinsically with payment and promotion but creative actions often arise out of a long-standing commitment to and interest in a particular area. She appreciates this is only one part of the equation, and that expertise in the domain concerned, and sufficient mental flexibility to question assumptions and play ideas, are also important. In addition, she points out the critical importance of challenge, for instance, matching people to tasks they are interested in and have expertise in, permitting people freedom as to how they achieve innovation, setting a sufficiently diverse team task of innovation, along with sufficient resources, encouragement and support.
Creative Processes

Some conceptualisations of creativity are closely related to the process of sensing problems or gaps of information, forming ideas or hypotheses, testing and modifying these assumptions and communicating the results. In this respect, creativity is the ability to see a situation in many ways (divergent thinking) and continuing to question until satisfaction is reached (convergent thinking) (Vidal, 2006a). In creative work, it is a good idea to separate these into two processes, first diverging and then converging. The creative process can involve tiny creative leaps or giant breakthroughs. Both require that an individual or a group go beyond where they have gone before, embracing the unknown, the mysterious, the change, and the puzzling without fear.

The term “divergent thinking” refers to that strategy of solving problems characterized by the proposal of a multiplicity of possible solutions in an attempt to determine the one that works. It usually happens in a free-flowing, spontaneous manner, where multiple creative ideas are engendered and evaluated. A manifold number of potential solutions are studied in a brief span of time, and unconventional connections may be drawn. Once the stage of divergent thinking is complete, information and ideas are structured and organized using convergent thinking. Brainstorming and free writing are two techniques that involve divergent thinking (VanGundy, 2005). Divergence is typically signified by the capacity to produce many, or a greater number of complicated or complex ideas from a single idea or simple triggers or ideas. It calls for making unexpected combinations, changing information into unanticipated forms, identifying connections among remote associates, and the like. In divergent thinking, a single question returns multiple answers, and though the answers vary considerably depending on the person, all answers are of equal value. Perhaps they did not exist ever before and so are novel, surprising or unusual. At times, this is true purely for the specific setting or in the experience of the person responsible for the variability in question. However, it may also be the case in an absolute sense. Divergent thinking has been detected in people with personality characteristics such as these – curiosity, nonconformity, persistence and readiness to take risks. Bubble mapping, creating artwork, maintaining a journal, subject mapping, devoting some time to meditation and thinking, and building lists of questions are all examples of activities that trigger divergent thinking.

Convergent thinking is a problem solving technique involving the bringing together different ideas from different participants or fields to determine a most satisfying solution to a lucidly defined problem. This term is an opposite term to “divergent thinking.” The focus for this thinking strategy is speed, logic and accuracy and on identifying the known, reapplying techniques, and amassing stored information. This strategy is best suited for situations characterized by a readily available answer that just has to be worked out or recalled by way of decision-making strategies. A vital facet of convergent thinking is that it culminates in one best answer, meaning there is no chance for ambiguity. You either have a right answer or a wrong one. This type of thinking is also associated with knowledge (one of the key facets of creativity) as it entails using existing knowledge by way of standard procedures. Mind Mapping and SWOT analysis are the tools usually used in this process (Vidal, 2006a).

Convergent and divergent thinking are similar in that both thinking strategies are used to determine solutions to problems. Not just that but both strategies are directed at determining the best solutions. It is frequently seen that problems are solved through a blend of divergent and convergent thinking. Divergent thinking brings out the best outcomes when it is used for open-ended problems that enable creativity. Convergent thinking is ideally suited for situations where there exists one best correct answer and it is feasible to determine the answer by way of evaluation of available stored information. In addition, though
it does not look the case, convergent thinking also contributes to idea generation. However, owing to the fact that the focus of divergent thinking is ideas rather than process, any solution determined as a result of divergent thinking, frequently needs convergent thinking to convert it into a practicable to-do-list. The use of divergent and convergent tools is an important task of a course about creativity.

**Group Creativity**

The creative process may be considered as a new way of seeing, a different point of view, an original idea or a new relationship between ideas. It is the way or manner in which a problem is solved. It is the process of bringing something new into being. It is the process of combining previously unrelated ideas or perceiving a new relationship from previously unrelated ideas. Whether solving problems alone or in a group, a person really must have a guided process i.e. a plan or a map of the steps to be followed. This is especially so in a group due to the need to align the capabilities of the members in a positive way. This map is usually called the Creative Problem Solving (CPS) process and under this denotation there exist a large number of methods, tools and techniques to support the creative process in group work related to problem solving tasks.

Group creativity has not been researched as much as individual creativity. Leonard and Swap (1999) presents their process for group creativity as five linear steps for discussion, while acknowledging that in practice it would look more like a “plate of spaghetti.” The five steps are:

1. Preparation,
2. Innovation opportunity,
3. Divergence: generating options,
4. Incubation, and
5. Convergence: selecting options.

This process parallels creative problem solving techniques that involve cycling repeatedly through a process of divergent and convergent thinking. Focusing first on group composition, the concept of “creative abrasion” is important. Creative abrasion is descriptive of the friction that is caused when a heterogeneous group works together to develop creative ideas. It is usually hypothesised that the relationship between creative abrasion and performance has an inverted-U shape. That is to say, at low or high levels of abrasion the group is less creative while at moderate levels of abrasion performance is maximized. Creative abrasion is caused by the diversity of the team members along dimensions such as individual professional expertise, cultural heritage, dominant thinking styles, etc. To have creative abrasion groups must have diversity along those same dimensions.

**Collective Creativity**

The current age of networked technologies increasingly requires teams with diverse skills and knowledge to collaboratively solve complex problems and create innovation. Studying creativity in collaborative work is acknowledged as a highly challenging, but increasingly vital endeavour for understanding how groups and societies innovate and progress over time. In response, more recent creativity research has moved beyond individual creativity to study the social and interactional dimensions of collective cre-
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ativity, at the level of dyads, groups, organisations and communities, and particularly in collaborative problem-solving and learning contexts.

From among the few studies undertaken in school settings, Chiu (2008) is directly relevant: group micro-creativity, operationalized as the number of new ideas manifested in high school students’ collaborative argumentation discourse in an algebra unit, was found to be positively associated with collaborative problem-solving success. In addition, group micro-creativity was found to be positively associated with ‘polite’, rather than ‘rude’ evaluative statements, and with ‘mutual grounding’ through the use of questions and responses, rather than the use of ‘instructive commands’. The term “micro-creativity” was used as the study focused primarily on one element of creativity, the divergent production of new ideas. Chiu (2008) acknowledged the need to extend this line of inquiry to encompass a more holistic conceptualisation and operationalization of creative behaviour in-group problem-solving contexts. A second directly relevant study, Cheng and Yang (2011), examined university students’ levels of collective creative efficacy (CCE), conceptualised as the shared belief in the team’s ability to collectively engage in a creative process to co-generate new and useful outcomes (in this case, novel software process improvement ideas). CCE was found to be positively correlated with better performance on selected tasks. The authors, however, recognised the limitation of focusing only on a limited component of creativity, that is, creative self-belief or potential. They urged future studies to examine different interaction patterns pertinent to CCE and more comprehensive dimensions of collective creativity.

To address these specific knowledge gaps, Tan et al (2014) build on the preceding critical examination and synthesis of literature in the fields of creativity, problem-solving and computer-supported collaborative learning to conceptualise CCE in CPS contexts as a multi-dimensional group expertise encompassing a suite of metacognitive, cognitive, social and communicative skills and sub-skill components, namely, reflexivity, divergent production, convergent production, and pro-social interaction. In sum, Tan et al (2014) articulate CCE as the group’s ability to collectively:

1. Plan, monitor and regulate shared objectives, strategies and solutions,
2. Generate and evaluate new ideas or solutions, and
3. Engage in pro-social communication in joint accomplishment of the task at hand.

Tan et al (2014) demonstrate the potential affordances of the proposed dialogic framework as a reliable and valid approach for assessing students’ collective creativity competencies in computer-supported collaborative problem-solving contexts. Having conceptualised and operationalized collective creativity as a suite of metacognitive, cognitive and sociocommunicative skills and sub-skills that are manifest and observable in multiple categories of students’ talk-in-interaction, they fore-grounded statistically significant and conceptually interpretable distinctions in the dialogic interactions of successful and unsuccessful CPS teams. In light of these findings, they emphasise the value of a dialogue based formative assessment approach that can make visible students’ collaborative discourse and interactional dynamics on problem solving tasks. This can in turn provide students and teachers with more productive recourse in the challenging endeavour of fostering more effective collaboration and creativity in joint problem-solving practices. They are hopeful that the dialogic framework and coding scheme presented here can be part of a global effort that augments current understandings and designs of formative assessments for cultivating essential 21st century collaborative and creative problem-solving skills in the students of a creative course.
Group Facilitation

To facilitate is: *to promote, to aid, to make easy, or to simplify*. In other words, a group facilitator is a person who supports the group (or team) during the task solving process. A team is a very experienced group where each individual can be the facilitator. In a workshop, a distinction is made between content (the theme under discussion), approaches (the way a problem is tackled), and social processes (group interaction and communication). Facilitation focuses primarily on approaches and processes of students’ learning (Vidal, 2004). That is, the facilitator does not need to be particularly an expert about the theme being discussed. Too much or too little knowledge on the subject matter might actually hinder the process of facilitation.

The task of a facilitator is usually compared to that of a football coach or the conductor of a symphony orchestra. As a coach, the facilitator sometimes knows very well the members of the group and he guides them to achieve some goals. As a conductor, the facilitator has to conduct an orchestra which he had not worked with previously and which will be improvising rather than performing a standard piece of music. It is precisely the need for flexibility and the unpredictability of the group processes that make the facilitation task as management so unpredictable and fascinating. The facilitator is there to ensure fruitful group processes whether this a brainstorming session for getting new ideas or using some tool to structure a complex situation. The role of the facilitator is to ensure that the group works as a constructive, collaborative, creative and cohesive unit. Therefore, the task of a facilitator has three elements: leadership, referee, and neutral (Schwarz, 1994).

The leadership role usually demands the following activities:

- **Focus:** To provide a focus for the group.
- **Stimulate:** To encourage constructive debate between the participants.
- **Support:** To bring out information from introverted participants and to allow new ideas to be submitted.
- **Participate:** When the group is interacting poorly or is going in the wrong direction, the facilitator must be willing to promote new discussions.
- **Team Building:** To form a cohesive, interactive, dynamic and creative group.

The referee role usually demands the following activities:

- **Regulation:** To maintain order of the group discussion, discouraging participants from talking at the same time, or dominating the floor.
- **Protect Participants:** To ensure that all contributions to the discussion are treated equally and that no one is rebuffed for their input.
- **Deal with Problems:** To control problem participants allowing everyone to participate freely.
- **Deal with Conflicts:** To identify conflicts and to create space for a fruitful discussion.
- **Timekeeper:** To adhere to workshop timetable thus ensuring completion of the agenda.

The neutral role usually demands the following activities:

- **Pragmatic:** To take detached look at the discussion viewing each issue on its merits.
- **Encourage Feedback:** To promote discussion of each selected issue, by all members of the group.
**Impartial:** To be neutral to the discussions, this frees the facilitator to focus on the process rather than the content of the discussion and hence asking pertinent and stimulating questions.

Summarizing, we can say that a facilitator is a person who has the job of empowering the participants to learn in an experiential group. An experiential group is one in which learning takes place through an active and consciously involvement of the whole person. The facilitator has been appointed to this task by the organisers of the workshop to carry out learning and problem solving processes and the group members voluntary accept the facilitator in this role. The designed course should permit to enhance the facilitation abilities of all students.

**LEARNING**

The course has been grounded on learning experiences and praxes from three related areas: Action Learning, Action Research and Experiential Learning. Action Learning (Revans, 2011) can be defined as a process in which a group of people come together more or less regularly to help each other to learn from their experiences. The participants typically come from different situations, where each of them was involved in different activities and faced individual problems. The current practice more often now is to set up an action-learning program within one organisation. It is not unusual for a team to consist of people with a common task or problem. In action learning, each participant draws different learning experiences. Action learning is more often used in organisational settings.

Action Research (Reason & Bradbury, 2008) is a process by which change and understanding can be pursued at the one time. It is usually described as cyclic, with action and critical reflection taking place in turn. The reflection is used to review the previous action and plan the next one. It is commonly done by a group of people. In action research, a team of people draws collective learning from a collective experience. Action research is more common in community and educational settings.

Experiential Learning (Kolb, 2014) is a process for drawing learning from experience. The experience can be something that is taking place, or more often is set up for the occasion by a trainer or facilitator. Clearly, both action research and action learning are about learning from experience. The experience is usually drawn from some task assumed by a person or a team.

All these learning experiences are cyclic. All involve action and reflection on that action. All have learning as one of their goals. We might say that experiential learning is the basis for the learning component of both action learning and action research. We could also say that both action learning and action research are intended to improve practice. Action research intends to introduce some change; action learning uses some intended change as a vehicle for learning through reflection. In action research, the learners draw there learning from the same change activity. All are stakeholders in this activity.

The experiential learning cycle appears to capture the main features of experiential learning, action research, and action learning. It consists of the following stages:

Action → Review → Planning → Action …

We could say, then, that experiential learning functions by a dual alternation: between action and reflection, between unconscious and conscious principles. By engaging with both of these in a cyclic procedure, we integrate them. There are many creative methods and techniques that can support the team
work at each stage. An essential element in the learning process is the motivation of the students. They should be free to find the problems to be solved and the methods to be used. The teacher will facilitate the students in these problem finding and problem solving processes.

Training of students’ creativity needs training concepts to be developed which tend to incentive responsibility with an emphasis on “freedom” rather than “order”. Thus, it needs to deal not only with technical problem solving, but also with more holistic creative processes, taking into consideration the most complex problems of reality today. These problems to be solved by the students have to adhere to such complex reality.

Summarizing, it can be formulated that the creativity course discussed in this chapter was based on the belief that learning occurs at the following contexts:

- Learning to deal with real-life problems,
- Learning about creative methods,
- Learning to work in groups,
- Learning about oneself,
- Learning to facilitate groups, and
- Learning how to learn.

**DESIGN AND ORGANIZATION**

The course had been designed for 25-35 students. From the beginning, each student will be member of a group that will work as a team during the whole course. Each group will usually be composed of 5 students. The course runs for a semester (usually 13 weeks). The teacher and students meet one morning every week from 8 a.m. to 12 o’clock. Lectures always start at 9.00 am. The structure of the course is very flexible so shorter or longer versions could easily be designed.

The course is based on a number of lectures, group exercises, oral presentations and more freely chosen mini-project to be made in the last part of the course. On the first day, the students get a course overview and will be introduced to the overall themes and fundamental ideas of the course. After the first course day, groups will be established as well as a creative method will be selected by the group that they should present orally to the other groups. To follow this course, a student has to be a member of a group! The course is divided into four parts.

In the first part of the course (usually 4 weeks), introductory lectures will be given and the groups will work with obligatory exercises. At the end of this part, each group has defined a problem (mini-project) to be solved in a creative way: in this mini-project, all groups work with a problem related to the join theme: design of products, systems or organization using creative methods. In the second part (2 weeks), the groups will present some creative methods. In the third part (5 weeks) of the course the groups will work with their mini-projects. In the last part (2 weeks), each group make an oral presentation of their achieved results. The following sections will elaborate about the contents of each part.

**First Part**

This part has been designed as a traditional course with seminal lectures and group exercises. The main purpose of the one-hour lectures is to give a holistic and multidisciplinary view of the field: *Creativity*
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and Problem Solving, focusing on theories, methods and applications. The references for these lectures are three papers:

- **Creativity and Problem Solving** (Vidal, 2004a): This paper presents some modern and interdisciplinary concepts about creativity and creative processes of special relevance for problem solvers and groups. Central publications in the area of Creativity and Problem Solving are briefly reviewed. Some creative tools (brainstorming, mind map, SWOT-analysis, etc) (Vidal, 2006a) and the Creative Problem Solving (CPS) approach (Couger, 1995) are also discussed. Finally, some applications of these concepts and tools are outlined. Some central references are presented for further study of themes related to creativity and creative tools.

- **Creativity and Strategy Development** (Sørensen & Vidal, 2006): This paper focuses on how creative thinking, processes and methods can support the strategy development and planning process in organizations. First, several fundamental concepts related to both strategy development and planning are stipulated. In addition, the concept of living organization is discussed as well as the interaction between strategy and creativity. Then, methodological ideas to support the strategy making process are presented enhancing the use of creative methods and tools. Finally, a case study related to the development of a strategy for organizational development using creativity tools is discussed.

- **The Vision Conference** (Vidal, 2006): This paper presents the principles behind the design and management of the Vision Conference: a one-day workshop in which a large group of participants meet to create ideas, projects and visions for the future activities of a local community or an organization. A case study from a local community in Denmark is also presented to illustrate the organization, planning and management of a Vision Conference. The paper focuses on the three central social processes of the conference: group work, problem solving and facilitation. The paper ends with a discussion of creativity and creativity techniques suitable for Vision Conferences.

The main goal of the group exercises is to form, prepare and develop the group to be able to work as a creative and purposeful team during the rest of the course. The four obligatory exercises are focusing on the following themes:

1. Exercise where the groups are supposed to solve four creative puzzles.
2. Exercise where the groups are supposed to solve a task in a creative way using two creative tools: brainstorming and mind mapping. The task is to design a logo for an international creativity conference.
3. Exercise where the groups work in a divergent manner suggesting proposals for possible mini-projects using brainstorming to diverge. Finally, they will select from 3 to 5 projects for a final one. These projects are usually related to the design of products, processes or organizations.
4. Exercise where the groups work in a convergent manner to find a final mini-project. Two creative tools will be used for project evaluation: SWOT-matrix and mind mapping.

Each exercise takes around 1 hour. In the rest of the time, around 2 hours, the groups work with the creative methods that they have adopted. This will be presented in the second part of the course.
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Second Part

This part runs for two weeks. In the first part of the course each group has already adopted a creative method. They have been studying and working with them and in this part each group will give an oral presentation of their method. The methods to be presented are:

- **Future Workshops:** The purpose of this method is to formulate innovative solutions and action proposals based on the participants’ own experiences, so that they can put these into practice. These proposals will usually be in relation to a local issue or challenge or in connection with the planning of local action concerning a particular development. A Future Workshop works best with 15-25 participants who are selected among those directly affected by the problem and who are in a position to remedy it. The Future Workshop is a local initiative, arranged at local level with local participation. This workshop incorporates a 3-phase work process beginning with a critical analysis of the current situation (the critical analysis phase). This analysis is then used to focus on future visions (the visionary phase) that are subjected to a reality check and then finally transformed into action proposals (the implementation phase). A Future Workshop can last a few hours or take place over several days. The most common model, however, is the 1-day workshop, where the morning is devoted to the critical analysis phase, the first part of the afternoon to the visionary phase and the last part of the afternoon to the implementation phase. Prior to the actual work of the Future Workshop, an oral presentation can be held outlining the workshop’s problems for participants (Vidal, 2006).

- **Synectics:** This is an approach to creative thinking that depends on understanding together, things or processes, which are apparently different. Its main tool is analogy or metaphor. The approach, which is often used by groups, can help to develop creative responses to problem solving, to retain new information, to assist in generating writing, and to explore different aspects of the problem. It helps users to break existing mind sets and internalize abstract concepts. Synectics can be used with all ages and works well with those who withdraw from traditional methods. Facilitators can use Synectics by leading the group to: Describe the Topic, Create Direct Analogies, Describe Personal Analogies, Identify Compressed Conflicts, Create a New Direct Analogy, and Re-examine the Original Topic (Gordon, 1961).

- **Sociodrama:** It is a way of simulating what happens in life in order to: explore social issues, develop greater understanding between groups and individuals, problem-solve and make decisions; experiment and try out new options, rehearse new roles and strategies and predict outcomes. Sociodrama is concerned with social learning in a group. A sociodramatist will base their work around an understanding of the roles people play, the systems within which they work and the social forces which impinge on the situation being examined. By using role reversal, doubling, sculpting and role playing within a number of different scenes, sociodrama is based on many of the principles of adult learning: it draws on people’s experiences; it is relevant to their concerns; it engages people in the learning process and follows the learning cycle of people being involved in a learning experience, which they have time to reflect and theorize upon afterwards before planning new actions. Sociodramatists are always concerned about the wider social, political and economic influences operating in any particular situation. The real world does not always work according to the textbook formulae. People make decisions from a combination of external and internal factors and sociodrama gives people the opportunity to explore these different facets. In the context
of education, sociodrama can be used in teaching to enable students to explore situations from a variety of viewpoints and gain a better understanding of why decisions were taken and what other options were on offer (Sternberg & Garcia, 2000).

- **Storytelling:** It is a workshop with the purpose to use stories to build common understanding of a problem. When people participate in a common experience, they assume that there is shared meaning about that experience. The participants will be invited to explore a situation from individual points-of-view with the intention of gathering collective information. Through personal stories, a group story about a problem will be constructed. Then the collective story can be revealed to identify the underlying strands that define the problem. The session will uncover about the problem: Shared history, Myths that exist, Assumptions held by individuals, Unique points-of-view, Archaeological foundations that are the underpinnings, and Existing/pre-existing roles. The intended results of the session will be: Mindset focused on hidden problems, Patient listening to others’ stories, Deepened learning/thinking, Talking in the “and” mode, Expanded examination of what a problem contains, Option-oriented thinking, Involved parties at one “table”, Suspension of judgment, and Creating a container for the problem and problem solvers. The session will create a space for students to learn, inquire, and reflect to enable the problem definition to emerge from the stories told (Allan et al., 2002).

- **TRIZ:** TRIZ is a Russian acronym for “Teoriya Resheniya Izobretatelskikh Zadatch”, a Theory of solving inventive problems or Theory of inventive problems solving (TIPS) developed by Genrich Altshuller and his colleagues since 1946. This is a methodology, tool set, knowledge base, and model-based technology for generating innovative ideas and solutions for problem solving. TRIZ provides tools and methods for use in problem formulation, system analysis, failure analysis, and patterns of system evolution (both ‘as-is’ and ‘could be’). TRIZ, in contrast to techniques such as brainstorming (which is based on random idea generation), aims to create an algorithmic approach to the invention of new systems, and the refinement of old systems (Clarke, 1997).

- **Morphological Analysis:** This is a method for exploring all the possible solutions to a multi-dimensional, non-quantified problem complex. In linguistics, it refers to identification of a word stemming from a full word form (see morpheme). As a problem structuring and problem-solving technique, morphological analysis was designed for multi-dimensional, non-quantifiable problems where causal modelling and simulation do not function well or at all. This approach was developed to address seemingly no reducible complexity. Using the technique of Cross Consistency Assessment (CCA) the system however does allow for reduction, not by reducing the number of variables involved, but by reducing the number of possible solutions through the elimination of the illogical solution combinations in a grid box. A detailed introduction to morphological modelling is given in Ritchey (1998).

These oral presentations should give information on the historical background, the method, and some applications of each approach. Students’ skills of creative presentations are enhanced. The group presenting a method should plan a discussion of the advantages and disadvantages of a method where all the students should participate. This activity will mainly develop students’ critical thinking skills.
Third Part

The following 5 weeks the students will work in groups with a practical project selected by them, approved and supported by the professor. Every week the professor will discuss with each group the different problems and task, the selection of methods, and the design of the most suitable approach, etc. Some examples of projects are the following:

- Creative selection of a theme for a Master Thesis,
- Application of the creative process to a real-life problem in an innovative way,
- Solving a problem that has been solved before using a creative method,
- Combination of rational and creative approaches to a real-life problem,
- Creative design of a web page,
- From an idea to business or how to start your own firm,
- Strategy development in an organization,
- Dealing with complex social problems,
- Design of computerized systems,
- Design of a product or a process,
- Design of a new board game,
- Design of a firm that uses depleted tires as main raw material,
- Design of an organization for foreign students,
- Design of a new canteen at the University,
- Design of an action plan for an eventual landing of aliens,
- To find applications of a new technology: intelligent glasses, and
- Design a school of tomorrow.

The students will search for information, apply the creative methods and tools, interview relevant stakeholders, discuss in groups, use creative techniques, and they will be supervised to write a paper about their project. The students are encouraged to integrate the activities that belong to different parts of the human brain, logical as well as intuitive, factual as well as imaginative, quantitative as well as qualitative. The CPS approach (Couger, 1995) will be the main guideline for the problem solving process, supplemented by methods and techniques used in a designed approach for the problem in question.

The five steps of the CPS approach are:

1. **Fact Finding:** Observe carefully and objectively, like a camera, while collecting information about the problematic situation. Explore and identify the facts of the situation. Action: who? what? where? when? why? how (is and is not)?

2. **Problem Finding:** Clarify the challenge or problematic situation by considering different ways of regarding and reflect on those possibilities. Action: in what ways might we…? how do we…?

3. **Idea Finding:** Look for more diverse ideas, alternatives, options, paths, ways, and approaches, use various methods and techniques (divergent thinking). Action: make new relationships, associations, connections, magnify, minify, combine, rearrange, change, reverse, turn upside down, and inside out.

4. **Solution Finding:** Examine ideas in new and different ways, from even more viewpoints and criteria; become aware of consequences, implications, and reactions to tentative idea/solution. Select
or combine ideas to create a plan of action (convergent thinking). Action: effect on whom? effect on what? how to improve?

5. **Acceptance Finding:** Develop a plan of action, considering all audiences that must accept a plan. Seeks ways of making the idea/solution more workable, acceptable, stronger, more effective, and more beneficial. Action: what objections will different groups have with the idea/plan? how might be set this plan into action? who is going to do that?

Experience has shown that it is recommendable in a CPS process, at each step to start with divergent thinking (brainstorming technique is usually used) to produce as many ideas or solutions as possible and thereafter to switch to convergent thinking (the mind mapping technique is usually used) for selecting the few most promising ideas. It is not unusual that in a group, some members will very easily diverge, originating a list of alternatives, while others will converge very fast by trying to select the best solution from the list and the rest will be passive not knowing what is required of them. Hence a facilitator needs to design a clear and visible process to align the group. The facilitator will support the process, will elaborate a plan of steps to be followed, will organize a work-shop, and will manage the whole problem solving process to secure that an action plan will be elaborated and implemented. The art of facilitation is an essential topic in our course, the students will work in groups, the group will be facilitated and a student will facilitate the group work.

**Fourth Part**

Each group will report the achieved results in the form of a scientific paper that could be published in an international journal. All groups will be advised on the art of writing creative papers. Finally the course ends with a conference where all groups will present their projects in an engaged and participative way. The schedule of the day is organized as an international conference. After the presentation of each group the students will discuss the used approach and will suggest alternative methods and problem solving processes.

**EVALUATIONS AND REFLECTIONS**

As mentioned above, on the first day, the students should be presented with the purpose of the course and the program to be followed. The students might suggest changes and modifications. Then, groups should be formed. Some few students dropped out of the course after the same day or they would not show up the next session. Usually, students book for more courses that they can cope in a semester and after the very first week they make a final decision about which courses they will follow. The main reason for dropping out of this course was the demand that the students should be members of a group. This required some social competences and commitment to a group of people that some students find rather difficult to satisfy. Most of the foreign students were coming just to follow this course and they combined with other courses, a whole package for a semester stay that can be financed by ERASMUS in the case of the European citizens. Others were coming from China, New Zealand, USA and others. Males and females were equally distributed; this was rare for the case of The Technical University where the majority of students are males. Moreover, the students were also equally distributed in Danes and foreigners.
At the Campus net of the University, the students can evaluate the course replying to a standard evaluation scheme. Around 65% of the students replied to this evaluation. Those students no replying were usually foreigners that were only coming for a semester. Summarizing, the students in these replies expressed:

- A high satisfaction with the course,
- A high satisfaction with this learning experience, and
- A high satisfaction with the teacher.

For most students, this course was the first time that they were confronted with the principles of Active Learning. Most of them had been from 3 to 4 years at the University. The students were overwhelmed about the possibility of taking responsibility for their own learning in teamwork. This course was not a burden, the students were happy to participate in all the activities in a cooperative and collaborative way using their competences and developing problem-solving abilities.

The students also praised the roles of the teacher. At the beginning of the course, the teacher used a hierarchical teaching style as a traditional teacher. In the second part, the groups took over the lecturing activities and the teacher became an adviser to the groups. Finally, at the last part of the course, the teacher will function as a facilitator.

Seen from the teacher’s chair, the objective of the course has usually been fulfilled. This will be reflected in the marks obtained by the students. These are normally distributed from more than satisfactory to excellent. Main weight will be given to the final report, while variations in the individual marks can occur due to the oral presentations and the personal engagement.

In this course, all the students have experienced to:

- Work in groups,
- Have some fun,
- Feel free enough to be creative (learn to fly!),
- Not get too embroiled in technicalities,
- Practice their communication skills,
- Practice some creative methodology,
- Practice some facilitation skills,
- Deal with real-life problems, and
- Learn from other groups.

This means that all the students obtain a grounded basis in creative tools and methods that can be used in their future work with other courses, work with their final thesis, and for their future professional life. Some students will be highly motivated to continue working with the teacher towards the design of a project that can be the subject for a Master Thesis. Some of these projects have been:

- The establishment of a consulting firm selling creativity,
- Strategy development for a management consulting firm,
- Creativity tools for small firms, and
- A multi-methodological approach for optimization.
Some engineering students find the demands of a creative role based in the principles of action learning, both unfamiliar and uncomfortable. It is, therefore, important that they learn methods that will help them to develop a creative attitude to problem-solving work. They need to be able to recognize when a creative approach is required and to be able to engage in a creative mode. In order to do this, they need to have an appropriate toolkit that will enable selection of the right tool and method for the task at hand. The informing part of these needs can be fulfilled through traditional teaching methods, but in order to gain experience it is essential that they be used in practice. It has long been recognized that Action Learning is the best approach for achieving this and developing recognition of creative ability, which is vital to the overall education of problem solvers.

One essential element in this course is what has been called Collaborative Learning. This means that students learn best when they are actively involved in the learning process and that they learn best when they work in small groups. They will be motivated for learning when parallel with the subject to be learned; they learn how to learn in a study team. Study teams are long-term groups existing over the course of a semester with stable membership whose primary responsibility is to provide members with support, encouragement, and assistance in completing course requirements and assignments when someone has missed a session. Collaborative learning is an effective way to deal with complex problems and at the same time to learn to learn in practice.

Another theme of interest is this course is based on what is known as Project-Based Learning approach that is pedagogically founded on constructivist learning in a setting represented by a learning cycle composed of four different ways of learning (Blumenfeld, 1991):

- **Concrete Experience (Direct Observation):** By focusing in the solution of real-life problems.
- **Active Experimentation (Synthesis, Design):** By solving problems in a participative way with the users.
- **Abstract Conceptualization (Modelling and Analysis):** By designing and facilitating problem-solving processes.
- **Reflective Observation (Evaluation, Comparison):** By evaluating the results of a creative process.

This cycle is repeated in the learning situation in the course. The student are grouped in teams, learn to work together in a project-oriented manner following the above-mentioned cycle in a no structured way. They learn via contextualized problem situations. Because of that, and all that goes with that, namely the dynamics of group work and independent investigation, they achieve higher levels of comprehension, develop more learning and knowledge-forming skills and more social skills as well.

Reflections and evaluations are usually supported by the Critical Theory of Habermas (McCarthy, 1979). As a philosopher and sociologist, he has mastered and creatively articulated an extraordinary range of specialized literature in the social sciences, social theory and the history of ideas in the provocative Critical Theory of Knowledge and Human Interests. Habermas (McCarthy, 1979) differentiates three primary generic cognitive areas in which human interest generates knowledge. These areas determine categories relevant to what we interpret as knowledge. That is, they are termed knowledge constitutive – they determine the mode of discovering knowledge and whether knowledge claims can be warranted. These areas define cognitive interests or learning domains, and are grounded in three different aspects of social existence – work, interaction and power.
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Work Knowledge broadly refers to the way one controls and manipulates one’s environment. This is commonly known as instrumental action – knowledge is based upon empirical investigation and governed by technical rules. The criterion of effective control of reality direct what is or is not appropriate action. The empirical-analytic sciences using hypothetical-deductive theories characterize this domain. Much of what we consider ‘scientific’ research domains – e.g. Physics, Chemistry and Biology and methods for problem solving are classified by Habermas as belonging to the domain of Work Knowledge (Cranton, 1996).

The Practical domain identifies human social interaction or communicative action. Social knowledge is governed by binding consensual norms, which define reciprocal expectations about behaviour between individuals. Social norms can be related to empirical or analytical propositions, but their validity is grounded only in the intersubjectivity of the mutual understanding of intentions. The criterion of clarification of conditions for communication and intersubjectivity (the understanding of meaning rather than causality) is used to determine what appropriate action is. Much of the historical-hermeneutic disciplines – social sciences, history, aesthetics, legal, ethnographic literary and so forth are classified by Habermas as belonging to the domain of the Practical Knowledge (Cranton, 1996).

The Emancipatory domain identifies self-knowledge or self-reflection. This involves interest in the way one’s history and biography has expressed itself in the way one sees oneself, one’s roles and social expectations. Emancipation is from libidinal, institutional or environmental forces, which limit our options and rational control over our lives but have been taken for granted as beyond human control. Insights gained through critical self-awareness are emancipatory in the sense that at least one can recognize the correct reasons for his or her problems. Knowledge is gained by self-emancipation through reflection leading to a transformed consciousness or perspective transformation. Examples of critical sciences include feminist theory, psychoanalysis and the critique of ideology, according to Habermas (Cranton, 1996).

Accordingly, the following questions are interesting: what are the competences achieved by the students of this course? The concept of competence consists of three dimensions: the know-what, the know-how and the know-why. It is inspired by Habermas’ type of knowledge: instrumental knowledge, practical knowledge and emancipatory knowledge (Cranton, 1996). Know-why when evaluating students had been described as potentially painful for the learner, as he/she will have his/her conception of the world disturbed and though it is not the goal, emancipatory learning probably occurs. Learning how to learn and creativity as a way to get liberated from routines can have some emancipating aspects. The two first dimensions are of relevance for our purpose. The know-what and the know-how are the most important types of knowledge for the problem solving students. It is necessary really to understand both know-what and know-how to achieved satisfying work in creative problem solving. All students have opportunities of achieving these competences in the course.

FINAL REMARKS

From a teacher’s perspective, it is fun to run such a course. The atmosphere is very cosy. Creative persons have a very refined sense of humour. The students show a great deal of participation, engagement and enthusiasm, although they have very different backgrounds and specialities. Motivation is the key factor for learning. It demands courage to run such a course as outlined above in a competitive academic environment where students have most often been rewarded for individual effort; collaboration may not come naturally or easily for everyone. The success of this experience is very much conditioned by student’s
participation and motivation. Students cannot be forced to be more creative in a collaborative way but at least the teachers can make them reflect about the importance of creativity. So the experience from this course shows that student learn best when they are actively involved in the learning processes. The rewards for the teacher are many: developing experiences in creative learning, getting in contact with creative students, enjoy the work as a creative supervisor, etc. But it is hard work; the teachers have to be open to new ideas and willing to learn all the time.

The teacher has to be:

- **Generous**: Given knowledge as presents,
- **Supportive**: Seeking that each group seeks for excellence in its work,
- **Reflective**: About the evolution of each student and the groups,
- **Creative**: Suggesting new ways to solve problems,
- **Emphatic**: Feeling the best way to learn for each student and group, and
- **“Radioactive”**: Emitting all the time a good atmosphere for work.

The experiences from this course have shown that it is possible to design a course for students with the purpose to teach creative thinking, creative problem solving and creative methods using a project-based learning process. Within this context, learning how to learn is a creative problem solving itself. In this way, learning gets very close to reality, in the sense that the learning situations are quite similar to one problem solvers’ experience in their jobs as consultants, experts, advisors or facilitators. In this course, the teacher has been an adviser, an expert, a supervisor or a facilitator depending on the actual situation. The teacher has also learned during such a course, as each person, each group, and each project have their own idiosyncrasies that deserve special care. The teacher has to be a very creative person, he (or she) has to have experience in facilitation of groups and he (or she) should be willing to experiment and enjoy solving new problems. Although the radical changes cannot be achieved by only one course, this course discussed in this chapter was part of a set of courses dealing challenges of creativity development in higher education with strategy development, planning, operational research, system sciences, computer sciences, and management, etc.

**REFERENCES**


**KEY TERMS AND DEFINITIONS**

**Action Learning**: The process in which a group of people come together more or less regularly to help each other to learn from their experiences.

**Action Research**: The process by which change and understanding can be pursued at the one time.

**Convergent Thinking**: A problem solving technique involving the bringing together different ideas from different participants or fields to determine a most satisfying solution to a lucidly defined problem.

**Creative Abrasion**: The description of the friction that is caused when a heterogeneous group works together to develop creative ideas.

**Creativity**: The ability to challenge assumptions, recognize patterns, see in new ways, make connections, take risks, and seize upon chance.

**Divergent Thinking**: The strategy of solving problems characterized by the proposal of a multiplicity of possible solutions in an attempt to determine the one that works.

**Experiential Learning**: The process for drawing learning from experience.

**Facilitate**: To promote, to aid, to make easy, or to simplify.
Chapter 6

Creativity Development through Inquiry-Based Learning in Biomedical Sciences

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ABSTRACT

The increasing complexity of biomedical research has led to new models for collaborative research at large scale. Big science projects require multidisciplinary teams and skills, such as creativity, to foster innovation. Higher education can play an important role in fostering creativity with active-learning strategies, such as the Inquiry-Based Learning (IBL) approach. In this chapter, we explain how the Universitat Pompeu Fabra (UPF) in Barcelona, Spain, used IBL to bring medicine and human biology students together to find creative solutions to solve a challenging problem in biomedicine. In this interprofessional experience, students were taught creative techniques in a creativity workshop. The positive results, which were highlighted by external evaluators for their high quality, demonstrate the value of these collaborative projects in encouraging creativity. We propose that integrating the IBL pedagogical methodology with creative techniques and interprofessionalism is a valuable approach for fostering students’ creativity and generative and research skills.

INTRODUCTION

During the late 20th and 21st centuries, science has experienced a revolution that has had massive impact on human development and in our everyday lives. This scientific revolution has also influenced society’s own vision of science: people tend to identify successful science with scientists who have a deep knowledge of a discipline and mastery of the scientific method (Nature Editorial, 2015). Actually, this is not completely true. There are other important requirements to match such success, such as the ability to think critically and to solve problems collaboratively, as well as good communication skills.
Furthermore, more skills are required in this age of information. This climate of change and innovative creativity has been valued as one of the main 21st century skills (Tan et al., 2009).

With globalization, the increasing complexity of biomedical research has led to new models for collaborative research at a large scale (Esparza & Yamada, 2007). Science has become a driver of innovation, and academic research has participated in large, expensive and collaborative big science projects, which are characterized by international multidisciplinary teams of scientists and experts (Vermeulen, 2010). This phenomenon, known as Big Science, is not a recent development: the nuclear physicist Alving Weinberg coined this term to describe the Manhattan Project, which developed the atomic bomb. This was not the only example of Big Science in history: another big biomedicine project and the prototype of big biology has been the Human Genome Project (HGP), in which Big Science and “Little” Science - that is, science performed on a smaller scale and usually carried out in small teams - joined forces. In these kind of projects, creativity of individual investigators is complemented with collaborative partnership and interprofessionalism, in which members of different domains work collaboratively towards a common purpose: to make discoveries that impact knowledge, future education and health care (Oandasan & Reeves, 2009). Investigators’ creativity can be augmented by a more targeted and collaborative plan and fostered by group thinking (Esparza & Yamada, 2007). Big Science can be an important way to harness the creativity of researchers, enhance innovation and supply resources to solve urgent health problems (Esparza and Yamada, 2007). Big biomedicine represents a new way of solving problems with the collaboration of Little Science approaches, to foster problem-solvers, collaboration, scientific creativity, discovery and innovation.

Creativity is an integral and intrinsic property of science and the scientific process. Scientists are constantly challenged to extend knowledge as new experts, and to combine seemingly unrelated information to create a new knowledge (Barrow, 2010). However, some circumstances have led to a phenomenon called incremental science, in which some scientists prefer to develop ideas that are based only on existing or similar products, rather than providing a source for innovation or new paradigms (Epstein, 2013).

The development of repetitive scientific inquiries and a lack of creativity in this domain is a reality that might have been influenced by traditional learning. It is known that nowadays students are expected to absorb more and more information (Adams et al., 2009). Lecture-based learning has been the predominant mode of instruction since universities were founded in Western Europe over 900 years ago (Brockliss, 1996), despite ample evidence that many students gain little new knowledge from traditional lectures (Hrepic et al., 2007). Moreover, it is well documented that these methods engender passive learning rather than active engagement, boredom rather than intellectual excitement, and linear thinking rather than cognitive flexibility (e.g., Halpern & Hakel, 2003; Nelson, 2008; Perkins & Wieman, 2008). Thus, students have little opportunity to develop generative skills such as problem solving, creative thinking, motivation, or persistence, which are all essential skills for thinking like creative scientists (Nature Editorial, 2015).

BACKGROUND

What Kind of Creativity Can Be Trained in University?

Most people identify creativity as the ability of individuals to generate novel ideas; nevertheless, creativity is much more than that. The concept of creativity, over the years, has proven to be elusive to define.
Creativity Development through Inquiry-Based Learning in Biomedical Sciences

However, it is possible to detect some common issues. In recent years, many researchers combine two or more aspects of the creative process, such creative product, creative person, and creative environment, when defining creativity (Amabile, 1996; Csikszentmihalyi, 1996; Sternberg, 2006). A definition proposed by Plucker et al. (2004) draws from a content analysis of different articles that explicitly defined creativity, which is meaningful to researchers and practicing educators:

Creativity is the interaction among aptitude, process and environment by which an individual or a group produces a perceptible product that is both novel and useful as defined within a social context. (Plucker et al., 2004).

In this definition, the concept of aptitude is influenced by Snow’s use of the term, which represents ability and affective influences such as attitude and motivation. It is also interesting to recognize the role of interaction, as it shatters the myth that creativity is a static trait that cannot be enhanced. In summary, creativity emerges from an interaction among certain aptitudes, specific cognitive processes, and influences from the environment in which the individual or group exists (Plucker et al., 2004).

Creativity is therefore also defined as a multicomponent process, in which several cognitive and affective elements take place. In this view, the creative act has two phases: a generative process, and an exploratory or evaluative phase (Finke et al., 1996).

During the generative process, the creative mind pictures a set of novel mental models as potential solutions to a problem. In the exploratory phase, the multiple options are evaluated, and the best one is selected. The two phases were characterized by Guilford (1950) as divergent thinking and convergent thinking. He defined divergent thinking as the ability to produce a broad range of associations to a given stimulus or to arrive at many solutions to a problem. In contrast, convergent thinking refers to the capacity to quickly focus on the one best solution to a problem. The idea that there are two stages to the creative process is consistent with results from cognition research indicating that there are two distinct modes of thought, associative and analytical (Neisser, 1963; Sloman, 1996). In the associative mode, thinking is defocused, suggestive, and intuitive, revealing remote or subtle connections between items that may or may not be correlated and that are usually not causally related (Burton, 2008). In the analytical mode, thought is focused and evaluative, more conducive to analyzing relationships of cause and effect (Runco, 2004). Actually, there is ample evidence that the creative process requires both divergent and convergent thinking and that it can be explained by reference to mental abilities (Haring-Smith, 2006; Kim, 2006; Sawyer, 2006; Kaufman & Sternberg, 2007) as well as cognitive processes (Simonton, 2004; Diamond et al., 2007; Vandervert et al., 2007).

Recent studies have increasingly highlighted the sociocultural and collective aspects of creativity (Sawyer, 2006, Sawyer & DeZutter, 2009). Thus, it is seen as a social and collaborative phenomenon that requires interaction processes with other individuals and is strongly influenced by environment as well as social and cultural properties (Hämäläinen & Vähäsantanen, 2011). Creativity is the ability to produce work that is both novel and appropriate, and it occurs in a collaborative context. So, the creative process has been defined as dynamic, fundamentally social, and necessarily collective and collaborative. Creativity has been considered the driver for innovation and a key factor for the development of personal, occupational, entrepreneurial, and social competences through lifelong learning. Combining individual knowledge, skills, and abilities gives a group the potential to be more creative together than its individual members. Factors such as individual motivation, group diversity, and conflict have been emphasized in group creative development (Zhou, 2012). In fact, knowledge is constructed in settings
of joint activity, where people are dedicated to learn and collaborate on shared tasks and issues that matter them. Knowledge creation is fundamentally a social process, which means that social interaction provides essential cognitive resources for human cognitive accomplishment (Zhou, 2012).

Furthermore, creativity can be identified either with “historical creativity” when an idea or a discovery is historically new, or with “personal creativity” when something is new in a personal sense. It can also be identified with “Big C Creativity” (BCC), or extraordinary creativity, and “Little C Creativity” (LCC), or everyday creativity. In summary, it seems logical to relate BCC with “revolutionary creativity” or with a process in which something emerges that is historically, socially, and universally new or valuable (Hämäläinen & Vähäsantanen, 2011), and LCC with what Craft (2001) calls possibility thinking. LCC encompasses innovation and development (Haigh, 2006) and occurs with a new product or idea created in a small community as a result of group collaboration (Hadzigeorgiou, 2012). Even though people think of BCC as a personal ability, extraordinary creativity exists within a social-cultural system (a domain or culture that sets symbolic rules, a person who brings new ideas, and a community of experts who validate the produced novelty) and is complemented with a social dimension (Hadzigeorgiou, 2012). In an effort to broaden the concept for use in educational context, Kauffman and Beghetto (2009) developed the Four C Model of creativity, which provides a framework for including creativity in the curriculum and helping students to develop their creativity to higher levels. This model describes the following levels of creative expression (Beghetto et al., 2012):

- **Mini-C or Interpretative Creativity:** When a new idea is presented by a student or a group of students that is personally meaningful but that is judged to be standard by the rest of the community.
- **Little-C or Everyday Creativity:** When an original and valuable project is developed by a student or a group of students that is not of a high-enough quality to be published in a professional journal.
- **Pro-C or Expert Creativity:** When a novel and useful idea arises in a professional context, such as the idea of the flipped classroom pioneered by Aaron Sams and Jonathan Bergman.
- **Big-C or Legendary Creativity:** When an idea appears that transforms history, such as the computer chip or the natural selection theory.

Within this framework, teachers can help students that are at the Mini-C level to jump to Little-C, and to allow creative contributions by encouraging them to better elaborate their ideas. Similarly, a teacher could work with students to move from Little-C to Pro-C. This achievement should be understood as a long-term goal, since it takes years of deliberate practice, but undergraduate studies might provide the tools to achieve it (Ericsson, 2006).

**Creativity in Science**

Creativity is intrinsically tied to the nature of science and scientific knowledge and is indeed the product of creative thinking (Beghetto et al., 2012). There is evidence that scientific creativity is complemented with a social dimension and emerges from interacting scientists (Latour & Woolgar, 1986), so it is considered a socio-related issue. In fact, the image of the lone scientist carrying out experiments in his or her laboratory to reveal great scientific insight is now very strange and almost a historical myth (Hadzigeorgiou, 2012). In contemporary times, interactions among scientists and different research groups play a catalytic role in the creation of knowledge (Hadzigeorgiou, 2012). Furthermore, interactions of
Creativity Development through Inquiry-Based Learning in Biomedical Sciences

scientists with peers at conferences, in interdisciplinary teams, and during professional reading facilitate
their creative approaches (Barrow, 2010).

The history of science has shown that aesthetic factors play a major role in theory construction and
in influencing scientific practice in general (Hadzigeorgiou, 2012). Many examples exist of non-rational
factors playing a role in how scientific theories are selected. One such factor is beauty—scientists prefer
theories that displaying properties such as simplicity or symmetry (Parsons, 2012). Creative thinking
is the production of novel or aesthetic ideas, which would include both art and science (Barrow, 2010).
In fact, the aesthetic dimension of science is more likely to be appreciated, as Eisner (1985) has argued,
if knowledge is seen as something that is constructed rather than something that we merely discover
or find. This romantic understanding of science gives primacy to the idea that knowledge is a human
construction and, therefore, such knowledge cannot even be considered outside the context of its con-
struction (Hadzigeorgiou, 2005). The history of science provides us with some examples of scientists
who were inspired by aesthetic factors: Einstein’s relativity theory was influenced by the distinctions
between the visible and the invisible, the blurred line between distance and nearness and the unifica-
tion of time and space (Hadzigeorgiou, 2012). Physicist Paul Dirac gave another example that claimed
“it is more important to have beauty in one’s equation than to have them fit the experiment” (Parsons,
2012). Finally, another remarkable example in biology is found in Watson and Crick’s discovery of the
structure of DNA. Crick simply called DNA “the molecule which has style” because of its structure and
function (Parsons, 2012).

The process of scientific inquiry is also integral to scientific creativity; this includes asking questions,
problem solving, designing and conducting investigations, forming hypotheses, formulating explana-
tions, and reflecting upon findings (Hadzigeorgiou, 2005). Finally, the role of imagery and imagination
in scientific creativity has also been extensively reported (Gardner, 1983; Johnson-Laid, 1983; 1987;

To explain scientific creativity, Hu and Adey (2002) combined the literature about creativity and
nature of science to propose a three-dimensional, scientific structure creativity model. This model, taking
into account the definition of creativity, combines the product, the trait, and the process. In it, scientific
products can be distinguished from technical products, advances in science knowledge, understanding
scientific phenomena, and scientific problem-solving. The second dimension can be described as the
characteristics of a creative person, which are fluency, flexibility, and originality, and the central features
of creativity as described by Torrance (1990). Fluency means the number of original ideas produced,
flexibility, the number of different categories of relevant responses, and originality, the statistical rarity
of responses. The third dimension, the process, can be distinguished by creative imagination and creative
thinking (Hu & Adey, 2002).

Fostering Creativity Development in Educational Programmes

As creativity is a driver for innovation and a key factor for development, promoting creativity has been
suggested as one of the priorities for education systems to achieve the challenges of the twenty-first
century (Zhou, 2012). Higher education institutions can play an important role in this process, and recent
literature shows that there is an increasing interest in addressing this issue. Some investigations exploring
how can university educators teach creatively and teach for creativity have been developed (Ma, 2006;
Scott, 2004b; DeHann, 2009).
Different creativity training strategies have been proposed depending on how creativity is understood. One way is to consider creativity as a cognitive process, in which new ideas are generated through knowledge. Nevertheless, creativity might also be framed by associational and affective mechanisms, as well as motivational facts that inspire individuals to engage in creative efforts. Furthermore, it also can be seen as an outcome of environmental opportunities (Scott & Mumford, 2004).

These different interpretations of creativity and the creative process might influence the strategies and design of creative training. If creativity is understood as mainly cognitive, with problem-solving seen as reaching an essential fact, techniques based on heuristics that help individuals apply expertise will be probably chosen to design creative training. If however it is viewed as something more related to associational mechanisms, imagery techniques will probably be used in training. Although creativity can be seen and interpreted in different ways, some general approaches must be identified in creative training, including cognitive, personality, motivational, social, and interactional (Scott & Mumford, 2004). Therefore, it is essential to consider the different focuses: the person who creates, the creative process, the environmental factors, and the outcome (Zhou, 2012).

This context of different creativity frameworks thus allows diverse creative training courses to be designed. Sometimes, theoretical models give the basis to carry out an integrated and programmatic set of creativity training interventions. Such training courses are seen in programmes developed from lateral thinking theories or creative problem-solving. However, other forms of creativity training courses exist that rely on assemblies of independent techniques (Scott & Mumford, 2004). It is also important to take into account the domain in which the creativity-training course will be implemented for its design. Most courses are based on general models and techniques, so they must be modified and adapted to a specific domain or discipline to foster and enhance individual creativity (Scott & Mumford, 2004).

Instructions that emphasize active-learning strategies are demonstrably more effective than traditional teaching in promoting creativity skills (Waldrop, 2015, Freeman et al., 2007, Barrow, 2010). In active-learning methodologies, students gain autonomy, are responsible for their own education, learn to work collaboratively, and retain information and knowledge for much longer, which they are able to apply in different contexts (Waldrop, 2015).

The inclusion of specific creativity training as part of a college curriculum can have positive effects (Hunsaker, 2005). In a careful meta-analysis, Scott et al. (2004) examined 70 instructional interventions designed to enhance and measure creative performance. They confirmed that these could be highly successful in enhancing divergent thinking, problem solving, and imaginative performance. Informing students about the nature of creativity and offering strategies for creative thinking were the most effective components of instruction. They concluded that pedagogical approaches, such as social modeling, cooperative learning, and project-based techniques that required newly acquired knowledge to be applied, led to the greatest improvements (Scott et al., 2004).

To train creativity in a science academic context, it is important to encourage students to ask more questions in their development of science concepts, foster the development of personal interest questions, investigate causes, effects, and consequences of their observations, and generate more high quality questions associated with their personal lives (Barrow, 2010). One way to foster students’ creativity is to use an educational model based on the selection of a long-term motivational problem that students attempt to solve. Creativity can be developed while students investigate various aspects to resolve the problem (Barrow, 2010).

Inquiry-based learning (IBL) is an optimal pedagogical approach to foster collaborative creativity and cognitive diversity. It models the general process of investigation that scientists use to answer ques-
Creativity Development through Inquiry-Based Learning in Biomedical Sciences

Tions in the real world. IBL emphasizes constructivist ideas of learning, where knowledge is built from experience and process, especially in a social context.

Knowledge is constructed in settings of joint activity, where people are dedicated to learn and to collaborate on shared tasks and issues that matter them, with knowledge creation fundamentally being a social process (Zhou, 2012). As Savery et al. have explained, IBL allows students to learn the skills needed to apply the acquired knowledge and find a viable solution to a complex problem. To reach successful outcomes, students need to consider alternative solutions, make choices based on evidences, investigate alternatives in different scenarios, and explore new questions (Hämäläinen & Vähäsantanen, 2011). Creative skills acquired by students through IBL are related to problem-solving and communication, as well as to learning autonomy and leadership (Tan et al., 2009). Furthermore, different approaches of inquiry can be implemented. One can distinguish here between full, when students engage in all features of inquiry, and partial, when students embark on fewer essential features of inquiry, and between open, when it is fully directed by students, and guided, when it is teacher-directed (Demir & Abell, 2010). In terms of authenticity, full and open inquiry would be a preferable approach for developing scientific creativity.

According to the latest studies, the focus of creative training has concentrated on the interaction between individuals and the environment (Zhou, 2012). In fact, to stimulate creativity in an educational context and environment, as IBL aims to do, it is important to foster improvisation, collaboration, and interaction between peers and to guarantee a free, flexible, and open environment (Hämäläinen & Vähäsantanen, 2011). It is also essential to be tolerant towards failure and to be brave enough to take risks, both of which require an emotionally safe environment (Mohd Daud et al., 2012). Setting up a positive, democratic, and less dogmatic and doctrinal environment is a key factor for fostering the development of scientific creativity (Hu et al., 2013). In this context, students are not afraid to apply knowledge and to solve problems, and they feel more autonomous and confident (Hu et al., 2013).

Furthermore, students can also be trained with IBL in techniques that are useful to promote creativity. Many techniques have been developed for this for either individuals working alone or for teams, even though promoting creativity in interactive group sessions is recommended, as it encourages participants to develop and share ideas and connections (Adams et al., 2009). Creative techniques can be used during both idea generation and evaluation steps. These can be classified as: stimulatory techniques (brainstorming, checklists, lateral thinking, and mind mapping) that promote alternative thinking and the identification of unexpected connections (Adams et al., 2009); parallel and creative thinking group techniques, such as the De Bono six hats technique; problem-solving techniques, such as morphological analysis; and, finally, expert facilitation techniques, such as TRIZ tools (Adams et al., 2009).

Other aspects are also relevant in creative training. Metacognition is defined as the executive processes that regulate the activity of cognition or awareness and the control of one’s own thinking (Hu et al., 2013). Some studies have demonstrated the essential role of metacognition for improving creative thinking. In fact, individuals who are able to internalize strategies, such as problem solving, inventive thinking, and decision making, can make them part of their habitual mode of thinking (Hu et al., 2013) and apply and transfer them to their daily life or other domains. Thus, characteristics of metacognition are important in the creative process and development, because of their power to enhance and accelerate individual scientific creativity.

In addition, when a working environment brings together individuals from different disciplines and domains and who have different perspectives, the creative potential is enhanced due to different points of views and ideas and to unexpected connections (Adams et al., 2009). In creativity training, this phenomenon of interprofessionalism can be very useful for developing and fostering the creative potential of
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students. Interprofessional education (IPE) implies the collaboration of members from different domains who learn from each other and who work collectively. Effective teaching strategies for IPE use interactive methods, such as problem-based learning or IBL, where small groups develop a learning environment based on interdisciplinary knowledge, skills, and attitudes. In IPE activities, students understand each other's professional roles, enhance their self-confidence, and, through collaboration and interaction, develop skills such as communication, teamwork, and creativity (Oandasan & Reeves, 2009).

Creativity Training Programmes in Biomedical Studies

Even though a lot of theory and research about creative and creativity training exists, few studies on this have been carried out in biomedical sciences.

De Haan (2009) described different approaches on how to integrate creativity instruction into scientific teaching. Some of these experiences were based on minor modifications of the traditional lecture that engendered active learning and cooperative problem solving. These are short activities that can be easily inserted into a lecture and that aim to promote peer-peer learning and to increase associative thinking. These activities include the use of peer instruction (Mazur, 1996), Just-in-Time-Teaching techniques, (Novak et al., 1999), and student response systems known as “clickers” (Knight & Wood, 2005; Crossgrove & Curran, 2008). Other strategies have proven to be more effective for enhancing scientific creative skills but require non-traditional courses that are based on constructivist principles (Ausubel, 1963, 2000; Duch et al., 2001; Nelson, 2008) and are focused on inquiry-based instruction, such as problem-based, project-based, and case-based learning strategies (Duch et al., 2001; Ebert-May & Hodder, 2008; Cloud-Hansen et al., 2008) or on “community-based inquiry”. In these approaches, students engage in research within a real-world context, which allows them to increase their content knowledge and their critical thinking skills (Quitadamo et al., 2008).

In the other hand, Adams has focused his work on reviewing different approaches and techniques that can be used in biomedical sciences to promote and foster creativity for researchers and professionals of biotech companies (Adams, 2009). He proposes to include some stimulatory techniques in interactive group sessions, such as: effective brainstorming and checklists; lateral thinking and mind mapping, which promote alternative thinking and the identification of unexpected connections, respectively; the six hats process, which promotes parallel, creative thinking in groups; morphological analysis, a matrix-based approach to problem solving; and the more elaborate synectics and TRIZ techniques, which are likely to require expert facilitation. Also, the create-process framework is proposed to train bioscientist students in the idea generation process, to be better prepared to overcome the bottlenecks that confront the biotechnologist in areas of great current significance, such as bioengineering, drug discovery, and stem cell research and therapy. This framework was developed by industrial and academics in a EU-funded project (Create Project, http://www.diegm.uniud.it/create), which aimed to design teaching materials to promote creativity based on “live” industrial cases. By examining different methodologies and techniques, they proposed the “Create Process” approach, which comprises the following five phases:

1. **Predisposition:** An environment and a structure conducive to creativity are established within an organization.
2. **External Mapping:** Analysis of the environment outside the organization and identification of new opportunities.
3. **Internal Mapping**: Analysis of internal resources that leads to identification of organizational opportunities and threats.
4. **Idea Generation**: The emergence of ideas.
5. **Evaluation**: Assessments of the idea generation phase.

THE INTEGRATED BIOMEDICINE EXPERIENCE IN THE SCHOOL OF HEALTH AND LIFE SCIENCES OF UNIVERSITAT POMPEU FABRA

Research Context

This school, founded in 1998, offers an undergraduate biology degree focused on the biomedical field and based on an innovative educational project. It is located in a biomedical research environment, between the University Hospital del Mar and the Barcelona Biomedical Research Park (PRBB), one of the largest hubs of biomedical research in southern Europe.

In 2004, the school initiated a pilot study to adapt its curriculum to the European Higher Education Area (EHEA), a process that finished in 2012. During this period, a hybrid PBL (H-PBL) curricula was implemented to foster the development of problem solving skills as well as of generic competences, such as team working, communication, and self-learning skills (Carrió et al., 2011).

The school recently (in 2008) included undergraduate degrees in human biology and medicine, both of which were fully adapted to the EHEA. In these, consolidated H-PBL curricula were introduced, and several learning activities were planned to encourage interprofessionalism among students from both degrees.

A series of compulsory PBL courses were introduced, named Integrated Medicine I, II, III, and IV for medical students, and Integrated Biomedicine I, II, and III for the biology students. In the third year, integrated medicine and biomedicine were fused to let students from both degrees work together, to finding creative solutions to solve an actual and challenging problem in biomedicine.

Designing the Learning Scenario to Foster Creativity

A learning scenario to facilitate the development of students’ creativity was designed to include four main elements: 1) an inquiry-learning approach was used in which students were free to decide what they wanted to investigate, and how; 2) a creativity workshop to train students in creative techniques was implemented; 3) interprofessionalism was promoted by letting students with different profiles (i.e., from medicine or human biology) to find a project in which common interests were reflected; and finally 4) the external interests of the projects were supported through external collaborators and evaluators.

Inquiry-Based Learning Approach

A full and open inquiry model was implemented in this course, so that students worked in collaboratively groups to conduct their research projects, while the teacher acted as a learning facilitator.

The main learning outcome aim of this course was for the students to acquire research and collaborative skills; more specifically, by the end of the course, the student should able to define a relevant and feasible research question, to formulate a hypothesis based on previous background, to determine
Creativity Development through Inquiry-Based Learning in Biomedical Sciences

methods for answering research questions, to plan and manage the project development, to draw conclusions, and to communicate the scientific results in different ways. Importantly, all these aspects require a collaborative environment.

The course was conducted over 10 weeks. At the beginning, a broad, ill-structured problem in biomedicine was presented to the students through a short (10 to 15 minute) edited video. Its objective was to show the key ideas to trigger the first brainstorming. The problems considered in the last four years were HIV and tuberculosis interaction, pandemic hepatitis C, current challenges in organ transplantation, and antibiotic resistance.

Students worked in groups of seven to nine members with a tutor, with a two-hour tutorial session per week. The plan for the tutorial sessions followed the research process. Each group had to define a research question to address the problem. They were free to choose any kind of approach, while they could argue a consistent working hypothesis and an appropriate methodology. They had several options to carry out their project; for instance, they could perform some experiments in the school laboratories, consult PRBB researchers, or use patient data from the hospital.

Students assigned different roles to the group members, such as coordinator, editor, or speaker. Table 1 summarizes the course plan.

Table 1. Description of the course plan

<table>
<thead>
<tr>
<th>Tutorial Sessions</th>
<th>Objectives</th>
<th>Learning Activities</th>
</tr>
</thead>
</table>
| 1                 | Problem introduction and brainstorming | • Brainstorm about the problem  
• Identify learning objectives  
• List possible research questions  
• Assign group roles and tasks |
| 2                 | Research question definition | • Discuss the students research  
• Select the research field and analyze the possible research questions  
• Identify relevant bibliography and resources to carry out the project |
| 3                 | Project definition | • Discuss the methodology and the variables to study  
• Feasibility analysis: estimate needs and costs  
• Prepare first report |
| 4                 | Project planning | • Plan the project development (data collection, interviews with external consultants, literature review)  
• Assign tasks  
• Feedback of the first report from the tutor |
|                   | Coordination meeting | • Meet with the groups' coordinators and the course coordinator to share the project ideas and organize the final symposium  
• Write the symposium programme |
| 5                 | Project supervision (I) | First analysis of the data collection |
| 6                 | Project supervision (II) | • Second analysis of the data collection  
• Prepare the second report |
| 7                 | Project supervision (III) | • Analyze the data and present results  
• Feedback of the second report from the tutor |
| 8                 | Final report preparation | • Final data analysis, interpretation and conclusions  
• Orientations for writing a scientific paper |
| 9                 | Final presentation preparation | Prepare the oral communication for the final symposium |
| 10                | Symposium | Present and discuss the 12 projects developed during the course |
Creativity Development through Inquiry-Based Learning in Biomedical Sciences

To guide the inquiry process, give feedback to students, and foster metacognition, a formative assessment plan in which students were actively involved was designed. The evaluation criteria were shared with students at the beginning of the course. They were asked to write two reports during the project development. The first had to include the research question relevance, the background, the hypothesis, and a first draft of the proposed methodology, while the second report included the preliminary results. Tutors and students assessed these reports, so the group of students had to present a self-assessment report, in which they were required to reflect about the project development process. The assessments from the tutor and the group were discussed in the tutorial sessions and were used to document student performances as well as to identify areas in need of improvement.

For the final evaluation, students went through a written report and an oral communication. The report had to be written as a scientific paper with the customary sections. Three teachers assessed the final report. Moreover, at the end of the course, the students organized a symposium to share and discuss the 12 projects. In this symposium, each group presented a short oral communication, and three experts on the proposed issue participated as external evaluators. Table 2 summarizes the evaluation tasks, their objectives, and their percentage in making up the final grade.

Creativity Workshop

A four-hour creativity workshop was implemented in addition to the tutorial sessions to increase the development of scientific creativity skills. This workshop fostered a deep reflection about creativity and its relevance in the biomedical field among students, and several creativity techniques and tools were provided for use in the students’ projects.

The workshop was performed in a classroom with four groups of students working independently and two trainers. It was organized in two sessions, the first aimed at training students in generating new ideas, and the second at assessing and improving the ideas.

Table 2. Description of the evaluation plan

<table>
<thead>
<tr>
<th>Evaluation Tasks</th>
<th>Individual vs. Group</th>
<th>What is Assessed?</th>
<th>When</th>
<th>Who Assesses?</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Report 1</td>
<td>Group</td>
<td>Definition of a research project</td>
<td>Week 3</td>
<td>Tutor and students</td>
<td>10%</td>
</tr>
<tr>
<td>Report 2</td>
<td>Group</td>
<td>Development of the project</td>
<td>Week 6</td>
<td>Tutor and students</td>
<td>20%</td>
</tr>
<tr>
<td>Final report</td>
<td>Group</td>
<td>Quality of the project and written scientific communication</td>
<td>Week 10</td>
<td>Three teachers</td>
<td>25%</td>
</tr>
<tr>
<td>Oral presentation to symposium</td>
<td>Group</td>
<td>Quality of the project and the oral scientific communication</td>
<td>Week 10</td>
<td>Three external experts</td>
<td>25%</td>
</tr>
<tr>
<td>Tutorial session participation</td>
<td>Individual</td>
<td>Responsibility, knowledge construction abilities, oral communication, and cooperative skills</td>
<td>Week 1-10</td>
<td>Tutors and students</td>
<td>20%</td>
</tr>
</tbody>
</table>
Creativity Development through Inquiry-Based Learning in Biomedical Sciences

The first session took place in the second week of the term, when students were defining their research projects. It started with a real-time questionnaire about the students’ beliefs on scientific creativity, followed by a debate about the role of creativity in biomedical professions.

After that, the tutors explained different techniques to explore new ideas that could be applied to the projects that the students were developing. The techniques were mainly based on effective brainstorming, heuristics, and different viewpoint analysis.

In the session of assessment and improvement of ideas, conducted in the fifth week of the term, students used different techniques to analyze and improve their projects. Table 3 summarizes the workshop plan describing the creativity techniques.

Interprofessionalism

Collaborations between medical physicians and biomedical scientists are essential in taking clinical problems to a research context. Successful collaborations will lead to the discovery of new solutions to the current biomedical challenges. For this reason, promoting the understanding of the collaborative opportunities that exist between physicians and biomedical scientists in the future is one of the aims of this school. In this context, the Integrated Medicine/Biomedicine course is one of the main activities to address this goal.

A team of twelve teachers, including physicians and biomedical researchers, was involved in the course design and implementation. Two of them are in charge of the coordination, one with a background in medicine and the other in biology.

Each year, the entire teacher team selected a complex biomedical problem. They chose problems that are socially relevant and have to be addressed by different health professionals. The problem was presented to the students at the beginning of the course. Students then worked in mixed groups of seven to nine medical and human biology students. They were required to discuss different ways to address the problem and to identify a research question that engaged all student profiles. Moreover, they needed to collaborate during all the project development.

External Projection

To foster the relevance of the projects developed by the students outside the university context, experts on the field topic collaborated as external consultants. Once students defined their research question, they were able to contact them for an interview, to get their opinion about their research approach, or to ask for some specific advice for the project development.

Also, an open symposium to share the developed projects was organized by the course coordinators and the students. At the middle of the course, the group coordinators and the course coordinator met to share their project ideas and to prepare the program of the symposium by categorizing the projects in different issues. At this step, three external evaluators were invited who were specialists in the research topic coming from different perspectives, such as clinical practice, biomedical research, or private companies. The feedback from the external evaluators was very important for the students as well as for the course coordinators, as it provided a way to know if the projects developed by the undergraduate students are aligned with the current interests in the biomedical field.
Table 3. Creativity workshop plan

<table>
<thead>
<tr>
<th>Session 1. Generate New Ideas</th>
<th>Activities</th>
<th>Objectives</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Debate the role of creativity in biomedical professions</td>
<td>To identify students’ previous ideas and concepts</td>
<td>Through a real-time questionnaire, students must state their beliefs about scientific creativity.</td>
<td></td>
</tr>
<tr>
<td>Brainstorming post-it</td>
<td>To produce a high number of new ideas in a short period of time</td>
<td>Participants have one or two minutes to think about the main problem. Each one has to write one idea or concept minimum in a post-it. Each post-it must be stuck on the wall. The group has to discuss all the concepts and ideas and then pick out and prioritize the ones which are useful for solving the problem.</td>
<td></td>
</tr>
<tr>
<td>Heuristics ideation</td>
<td>To generate new concepts, ideas, products, or solutions using different concept connection</td>
<td>Participants have to write two different lists that include 1) motivational concepts or issues in the science field, and 2) the ideas from the brainstorming. The group has to connect and associate concepts from the two lists and generate new ideas.</td>
<td></td>
</tr>
<tr>
<td>Role storming</td>
<td>To generate and analyze ideas from different point of view</td>
<td>Participants must choose a person or a personality who causes admiration or aversion. They have to think what would this person think about their project. Afterwards, they have to analyze and discuss the emerged ideas.</td>
<td></td>
</tr>
<tr>
<td>Six hats (De Bono, 1999)</td>
<td>To promote problem-solving and analysis from different perspectives</td>
<td>Each participant has a hat, which symbolizes a thinking manner: emotion, creativity, optimism, information, control, or logic. Participants must answer all the questions related to their specific hat and the main problem.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Session 2. Ideas Assessment and Improvement</th>
<th>Activities</th>
<th>Objectives</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strange object</td>
<td>To promote the use of analogies to change the reference framework where we look for solutions</td>
<td>Participants write an analogy between a a strange or daily life object.</td>
<td></td>
</tr>
<tr>
<td>Ishikawa diagram (Ishikawa, 1968)</td>
<td>● To identify and establish connections between a problem and its possible causes ● To reorganize concepts and ideas linked to a project</td>
<td>This diagram is useful to reorganize and identify factors related to a main problem. The identified concepts and ideas must be grouped in different categories connected to the problem or the project.</td>
<td></td>
</tr>
<tr>
<td>The project illness</td>
<td>To analyze the project and find ideas to improve it through an analogy</td>
<td>Participants must imagine the project is ill. They then have to write a description of the disease and determine a treatment.</td>
<td></td>
</tr>
<tr>
<td>SCAMPER (Eberle, 1984)</td>
<td>To find new ideas to improve the product or process developed during the project</td>
<td>Participants must ask questions related to the following SCAMPER verbs, to come up with new ideas to improve the project: Substitute, Combine, Adapt, Modify, Put to other purposes, Eliminate, and Replace.</td>
<td></td>
</tr>
<tr>
<td>Logo design</td>
<td>To synthesise the main project idea through symbolic language</td>
<td>Participants must design a logo for their own project.</td>
<td></td>
</tr>
</tbody>
</table>

Results of the Experience: The Course Development

Most of the students were very engaged with the course development. During the first weeks, they conducted a deep literature review and proposed several project ideas. However, in some groups the re-
search question choosing was not easy. Additionally, some conflicts between human biology and medical students were identified: while the former were highly motivated to perform laboratory experiments and study basic biological mechanisms, the latter were more interested in analyzing clinical data or in following more applied approaches. The tutors initially tried to help students reach a consensus in which both groups of students felt comfortable. However, these disagreements often contributed to creative ideas, so that tutors identified these situations as opportunities to find out new ideas rather than mere collisions of interests. For example, in a group working with the HIV and tuberculosis (TB) problem, some students were very interested in understanding the mechanisms of *Mycobacterium tuberculosis* infection and why was so difficult to diagnose, others wanted to study how to improve the HIV-TB situation in poor countries, and the remaining were interested in new biotechnologies. At the end, they developed a project called “new TB diagnostic test based on biomarkers and bioactive papers,” in which they designed a new diagnostics test prototype for poor countries, which aimed to be quicker and cheaper and to require no professional support. After conducting a metanalysis on TB biomarkers, they contacted a laboratory that was working in bioactive paper tests to perform some experiments. In this project, the students developed their own interests and distributed the tasks based on specific interest. Thus, medical students were involved in identifying which were the current problems with TB diagnosis and how a good TB test for poor countries should be done, while human biology students were more prone to carry out the metanalysis of biomarkers and the molecular design of the new test.

Students developed different kinds of projects. Some conducted experimental projects carried out in the School laboratories or in professional laboratories, while others were based on clinical data analysis, surveys, metanalysis, bioinformatics, health protocols design, or mobile application developments. In some cases, students had brilliant ideas that were not possible to develop due to constraints of time and/or resources, so that they instead presented the project as a detailed proposal. The list of the projects developed in the four editions of the course is summarized in Table 4.

The external evaluators who participated in the four symposiums highlighted the high quality of all the projects and the creative ideas that students presented. In some cases, experts proposed to students to develop *a posteriori* their projects in a professional context. This was the case of a project developed by a group of students that using bioinformatics tools: they identified a new substrate for the NS3/4A protease of hepatitis C virus. The molecular virology group from UPF was very interested in this finding, and they involved the students in carrying out the experimental work to test the hypothesis. Also, a mobile application for transplantation patients, focused on providing useful information and facilitating the doctor-patient contact, was designed by a group of students and later implemented in the Hospital del Mar (Barcelona).

The grade given for these projects is a further indicator about their quality. In general, grades were very good: the mean qualification for the oral communication among the four academic years was from 8.2 to 8.9 out of 10, and the grades qualification for the scientific papers written by the students ranged from 8 to 8.8 out of 10.

**The Students’ Opinions**

Students’ opinions were collected through an open questionnaire, in which they were asked to highlight the strengths and the weaknesses of the course.

Some students found that this course fostered their personal and professional development; they said that it was like a trial for their future professional life. Others emphasized that having the freedom to
Table 4. Student projects presented in the UPF Integrated Biomedicine course Symposium over a four-year period (2011-2015)

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<td>HCV treatment: connection between a IL28B gene variant and IFN93 and ISG15 levels.</td>
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<td>level.</td>
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<td>Study of TB variables as a method to improve the action plan established in Barcelona.</td>
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<td>Action plan against tuberculosis in Catalunya, can it be improved?</td>
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<td>A non-invasive method for early detection of acute rejection in kidney transplantation through biomarkers combination.</td>
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<td>ATR polymorphism role in NK cells-T lymphocytes regulation and possible implications in the development of acute kidney rejection.</td>
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<td>Generation of cross-resistance in E.coli caused by soaps with triclosan.</td>
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<td>Probiotics: a potential reservoir of antibiotic resistance genes.</td>
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<td>Comparison between a natural probiotic and an industrial one.</td>
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<td><strong>Antibiotics’ alternative therapies</strong></td>
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<td>Design of a Phase III study: bacteriophages as an alternative to antibiotics.</td>
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<td>Hepcidin Project: peptide modification for a novel therapy in resistant P. aeruginosa.</td>
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<td>Nanoparticles, effective alternative for Pseudomonas aeruginosa multiresistant sepsis treatment.</td>
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<td>Association between the educational framework and antibiotics’ use and knowledge.</td>
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<td>Gamification to promote the proper use of antibiotics in young people.</td>
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<td>The effectiveness depends on you. Awareness campaign on the proper use of antibiotics.</td>
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<td>Integrated detection of serum biomarkers in BOS.</td>
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<td>Pig multitransgenesis to obtain organs in xenotransplantation.</td>
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<td>Parkinson disease: genetically modified stem cells treatment.</td>
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<td>Nanoparticles, effective alternative for Pseudomonas aeruginosa multiresistant sepsis treatment.</td>
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<td>Gamification to promote the proper use of antibiotics in young people.</td>
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choose their research project stimulated their initiative skills and was highly motivating. Some students also stressed that it helped them to improve their self-confidence, by learning how to materialize their own ideas.

Other positive aspects raised by the students included working with different people: students felt that more creative ideas arose from working with those with different abilities and motivations. Indeed, most of the students found that working in groups from different undergraduate studies was very interesting, despite having different interests and working styles. Some explained that although finding a project with common interests was not easy, it was very useful for understanding different viewpoints. Some biology students thought they were more creative and more engaged in carrying out risky projects. Generally, medical students were not as interested as biologists in developing experimental work in a laboratory. In contrast, they were more engaged in developing projects that included clinical data analyses. On the other hand, different strategies to work in a team between the both groups of students were identified, with biologists students more used to working cooperatively as compared to medical students. For these reasons, students from both groups proposed to start working together from the first year of their degrees.

In terms of conceptual learning, some students emphasized that the concepts learned through the problem-based learning courses were the most retained. They attributed this to being responsible for their own learning.

The limitations of the course pointed out by the students were mainly based on resources and time. Some students pointed out that ten weeks was not enough to develop a project, and they suggested increasing the time devoted to this course. On the other hand, groups that decided to perform experimental work suggested either to have more resources from the beginning of the course or to be able to go to professional laboratories to perform the experiments.

The Course Coordinators’ Opinions

The course coordinators were very satisfied with the students’ outcomes. They attributed the quality of the projects mainly to two aspects: 1) the students’ motivation and their consequent involvement with the research, and 2) the close supervision by the tutors.

Giving the students the freedom to design their own projects was one of the factors that led to the greatest degree of student motivation but was also the most difficult aspect to coordinate. This was more complex with experimental projects, as the laboratories availability and the required materials were not easy to organize. Students who wanted to do experimental work had to send a list of the required materials and laboratory facilities to the course coordinators by the third week. Thereafter, feasibility of the proposals was evaluated considering the cost, the required laboratory time, and the relevance of the project. For projects that were evaluated with high scores, the required materials were bought and the laboratory facilities were reserved. This coordination task had to be fast in order to give the students enough time to perform their experimental work. Thus, the students’ suggestion to perform their experimental projects in professional laboratories could be an alternative approach. Moreover, this strategy could reinforce the external projection of the projects, which was very highly valued by students.

On the other hand, the tutor’s supervision was also considered a relevant factor for the project development. Different styles of supervision were identified, and not all of them were successful at fostering creativity. In this sense, the creativity workshop was very useful, since it allowed students to reflect about their project in a more flexible environment that was guided by the creativity techniques, and coordinators stressed that it was also an element important for generating more creative projects.
CONCLUSION

The scientific revolution produced in the last decade demands further requirements apart from deep science knowledge. Critical thinking, problem-solving, and creativity are main skills in this climate of change and innovation (Tan, 2009). With the globalization phenomenon, the complexity of biomedical research has increased and has led to new models for collaborative research at large scale (Esparza & Yamada, 2007). These big science projects are characterized by international multidisciplinary teams of scientists combining big biology with science performed at a smaller scale. To lead to discoveries that increase knowledge and enhance innovation, creativity from both researchers and small groups is needed (Esparza & Yamada, 2007). Creativity in science has been proposed to be an important factor to foster innovation or new paradigms and to carry out these kinds of projects; nevertheless, it has also been defined as an essential skill to fight repetitive science based on existing products (Adams et al., 2009).

It is well documented that educational methods that engender active engagement, intellectual excitement, and cognitive flexibility enhance the development of generative skills, such as problem solving, creative thinking, motivation, and persistence, which are indispensable skills to think like creative scientists (Nature Editorial, 2015). In fact, active learning has been defined as a good scenario to promote creativity in higher education due to its common social and collaborative nature, which implies interaction processes with other individuals. Within this framework, teachers can help students who are at the mini-C (interpretative creativity) level to rise to the Little-C (everyday creativity) or Pro-C (expert creativity), and to allow creative contributions by encouraging students to better elaborate their ideas (Beghetto et al., 2012; Ericsson, 2006).

As mentioned above, higher education can play an important role in fostering creativity. Actually, active-learning strategies have been demonstrated to be more effective than traditional learning in promoting creativity skills, as these pedagogical methodologies allow students to gain autonomy and to learn to work collaboratively (Waldrop, 2015, Freeman et al., 2007, Barrow, 2010). Inquiry-based learning (IBL), described as an active-learning methodology, is an optimal approach for engaging students in a research process from the beginning and for fostering collaborative creativity and cognitive diversity throughout the experience in a social context. Through IBL, students can increase their creative skills related to problem-solving and communication, as well as learn autonomy and leadership (Hämäläinen & Vähäsantanen, 2011). In this context, the focus of creative promotion and training has been concentrated on the interaction between individuals and the environment. Moreover, in a free and collaborative environment where improvisation and interaction between peers are fostered, students can be trained in techniques that are useful for promoting creativity, some of which can be helpful during the creative process for idea generation and during the evaluation steps (Adams et al., 2009).

In the UPF experience, an IBL approach allowed students, from medicine and human biology, to work together to find out creative solutions to an actual and challenging problem in biomedicine, in which they were free to decide what they want to investigate and how. Students worked in collaborative groups to conduct their research projects, while the teacher acted as a learning facilitator. Throughout this active-learning methodology, students worked in a collaborative environment and gained important generative and research skills essentials in problem-solving and scientific creativity thinking. Students were required to consider alternative solutions, investigate different scenarios, explore new questions, and make choices based on evidence. These intellectual challenges promoted divergent thinking as well as creative ideas to reach their goal. To increase their creative skills, a creativity workshop was integrated in the inquiry course to train students in creative techniques during interactive group sessions, which
encouraged participants to develop and share ideas and connections. Through this workshop, students understood the importance of scientific creativity and divergent thinking in the biomedical field and were provided with useful tools to promote their problem-solving and creative thinking. Furthermore, in this IBL approach, interprofessionalism was introduced by letting students from different profile find a project which reflected common interests; here, disagreements, interdisciplinarity, the creation of unexpected connections, interactions, and other perspectives and points of view often facilitated their creative approach and contributed to emerging creative ideas. Finally, to determine the relevance, value, usefulness, and originality of the projects, an external committee evaluated projects.

The results of this experience revealed that collaborative projects performed by students are creative. The external evaluators who participated in the symposiums and presentations of these projects highlighted their high quality and the creative ideas that students presented. Moreover, students perceived that they have developed their creativity due to their freedom to choose their research project, leading to an increase in their self-confidence. They also thought that they had more creative ideas after working with people with different abilities and motivations. After these results, we think that integrating the IBL pedagogical methodology with creative techniques and interprofessionalism is a strong approach for fostering creativity. Nevertheless, further research is needed: it will be a great success to identify which concrete activities promote creativity in a better way, and also which kind of actions performed by tutors could develop and enhance creativity in their groups. Finally, it will be interesting to measure if creative skills increase at the individual level, and not only at the collaborative level.

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Creativity Development through Inquiry-Based Learning in Biomedical Sciences


Creativity Development through Inquiry-Based Learning in Biomedical Sciences


**KEY TERMS AND DEFINITIONS**

**Active Learning:** An educational model that includes different methodologies (such as PBL) to engage students in their own learning and to provide them with more autonomy, participation, and action.
Collaborative Learning: The situation in which a group of individuals create knowledge throughout interaction, experience, and the assumption of roles.

Creativity: A social and collaborative phenomenon in which something new, valuable, and useful emerges.

Critical Thinking: The skill or ability to analyze and evaluate something and draw reasoned judgments.

Inquiry-Based Learning: A pedagogical approach that models the process of investigation used by scientists to answer questions in real life. This methodology fosters the development of some skills, such as collaborative work, creativity, autonomy, problem-solving, etc.

Interprofessionalism: The collaboration of individuals from different domains who work together and learn from each other to create knowledge.

Undergraduate Biomedical Education: The undergraduate studies that include Medicine and the Human Biology and Biomedicine degrees.
Chapter 7

Distributed Problem-Solving: How Artists’ Participatory Strategies Can Inspire Creativity in Higher Education

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Aalborg University, Denmark

ABSTRACT

This chapter aims to deconstruct some persistent myths about creativity: the myth of individualism and of the genius. By looking at literature that approaches creativity as a participatory and distributed phenomenon and by bringing empirical evidence from artists’ studios, the author presents a perspective that is relevant to higher education. The focus here is on how artists solve problems in distributed paths, and on the elements of creative collaboration. Creative problem-solving will be looked at as an ongoing dialogue that artists engage with themselves, with others, with recipients and with materials, in asynchronous or synchronous relationships. The empirical background draws on qualitative narratives collected in 2011-2014 and based on interviews with recognized artists. The questions guiding the present chapter are: If creativity does not arise from talent but from exercise and hard work, what can educators at higher education learn from the ways creative groups solve problems? How can artists contribute to inspiring higher education?

BEYOND THE CREATIVITY MYTH

A number of approaches to creativity emphasize talent and individual processes as the basis for the generation of creative output. Guildford (1956) and Torrance (1962), for instance, come to the conclusion that individual talent is essential to creativity. The talent-approach to creativity has essentially two ontological consequences: first of all, creativity is something individuals are born with, a psychological trait that individuals do or do not “have”; secondly, creativity occurs at individual level. The myth of the lonely genius is still very rooted in Western mind-sets and has a long history (Chemi, Jensen & Hersted, 2015). Several contributions have conceptually and empirically challenged these assumptions. Creative processes are essentially based more on motivation and sustained hard work (Amabile, 2011) than on talent, individuals are actually creative against the background of continuous collaboration (Sawyer, 2012).
Distributed Problem-Solving

and the craft implied in solving creative problems is based on and nurtured by challenging, meaningful, engaging work done with, for and among others. Discovering the workings of the ways in which creative individuals and groups practice collaborative strategies is still a challenge. This is partly because creative processes can be tacit (Polanyi, 1962), experiential (Dewey, 2005) or internalized (Vygotski, 1997) and therefore can be difficult to explain in words, but also partly because studies looking deeply at creativity as collaborative, distributed and relational are still young in their broader dissemination. In other words, even though the pluralistic perspective can count at least 15 years of contributions, these studies have not been fully integrated into common knowledge about creativity, which still is perceived as the act of geniuses and specially gifted individuals. Clearly, the distributed and collaborative perspective must deal with myths going back to the nineteenth century that are deeply rooted.

This chapter aims to deconstruct such myths by looking at literature that approaches creativity as a participatory and distributed phenomenon and by bringing empirical evidence from artists’ studios, looking at how artists solve problems in distributed paths. The implications of the elements of creative collaboration for education are several. If creativity does not arise from talent but from exercise and hard work, this means that creative techniques can be learned and taught. If educators can engage learners in creative training, what is the consequence for higher education? What can educators at higher education learn from the ways creative groups solve problems? How can artists contribute to inspiring higher education? These will be the questions guiding the present chapter.

LOOKING AT AND LISTENING TO ARTISTS SOLVING PROBLEMS

The empirical background of this chapter draws on qualitative narratives, which were collected in 2011-2014, in collaboration with colleagues from the research group ARiEL (Arts in Education and Learning), based at Aalborg University. In this study, professional artists’ narratives were gathered on the topics of cognitive, emotional and relational elements of creative processes (Chemi, Jensen & Hersted, 2015). The focus of data collection was on the specific qualities of creative and learning processes as interconnected to each other. Although this research was not originally intended to focus on understanding higher education issues, it became clear afterwards that adult and higher education could draw a great number of insights into creative learning and teaching from the collected data, for instance, by discussing the study’s consistent findings on creative processes, motivation and identity. This chapter will focus on one specific element of the creative process - problem-solving, especially in participatory settings. Digging specifically into the artists’ compositional strategies could provide new insights and inspiration for innovative approaches to higher education.

Creativity is not to be understood here as a phenomenon exclusive to the arts, just because the main focus is on the domain-specific form of artistic creativity. Many different professional fields cultivate and need creativity. However, because studies on creativity show the necessity for more focused attention on the specific domain of artistic creativity, this chapter will look at the clearly delimited strategy of problem-solving in artists and artistic communities. These communities seem to cultivate and nurture creativity as one of the basic means and ends of their learning, communication, expression and engagement in relationships and collaboration (for the debate on domain-specificity see Baer 2010). Within artistic professions, creativity is not only a basic need but also a well-acknowledged expectation. Not only does one accept acts of creativity from artists, but also one expects artists to solve problems creatively. Therefore, the research behind this chapter sampled full-time professional artists (the so-called Pro-C
level of creativity, the professionals) who had made an original contribution to the domain in which they operated, who were broadly recognized (the Big-C level of creativity) and who had demonstrated a clear interest in meta-reflections and artistic conceptualizations (Csikszentmihalyi, 1996). The artists sampled could be defined as experts in the arts, as they had tipped the point of expertise, the famous 10,000 hours or ten years of practice that seem to enable individuals to challenge the very rules of their domain (Feldman 1999, p. 173, Gardner 1993).

The methodological approach is qualitative and based on retrospective narratives, collected by means of semi-structured interviews. The 22 artists interviewed (11 females, 11 males, average age 53.5, standard deviation 14.7σ) produced more than 23 interview hours divided in 18 interviews (some collaborating artists were interviewed in pairs). Interviews were recorded, transcribed, where necessary translated and analyzed. All the artists agreed to be quoted by name and even contributed to the texts’ internal validity by giving us feedback on content and formulations in their own transcribed interview. They covered a wide variety of art forms and genres: literature, poetry and scriptwriting (Siri Hustvedt, Morten Ramsland, Michael Valeur); dance and choreography (Palle Granhøj); acting and theatre directing (Eugenio Barba, Julia Varley, Kirsten Dehlholm); music (Anders Koppel, Benjamin Koppel, Marco Nisticò, The Mira Quartet); film-making (Annette K. Olesen, Mary Jordan); visual arts (Michael Kvium, Julie Nord); digital arts (Signe Klejs, Niels Rønsholdt); design (Rosan Bosch, Rune Fjord); architecture (Inger Exner, Johannes Exner). The reason for this wide representation of art forms was the research focus on commonalities among different artistic approaches. The present chapter will not extensively indulge in the topic of what art is, because this is still largely unanswered in aesthetics and its discussion is not fully relevant to this chapter. However, as a working definition, art can be seen as something that is man-made, by means of skills and crafts, involving media, materials and meanings, something that is shared with and meaningful to others. This study draws on this broad working definition and therefore includes several art forms, styles and genres in its empirical background.

The lessons learned in these conversations will be used as inspirational sources for stimulating a creative approach to higher education.

CREATIVITY REFRAMED

This chapter looks at artistic creative processes and reformulates the focus of these processes as a research strategy based on the finding of novel problems, strategy that occurs in distributed trajectories. It is not the chapter’s ambition here to review the many different perspectives on and definitions of creativity, as others have greatly contributed to this task (Kaufman & Sternberg, 2010). A definition by way of introduction is, however, necessary. Creativity is here defined according to socio-cultural approaches, as consensual: the “interaction among aptitude, process, and environment by which an individual or group produces a perceptible product that is both novel and useful as defined within a social context” (Plucker, Beghetto & Dow, 2004, p. 90). In other words, creativity is a social negotiation that occurs in given cultural spaces. Artistic creativity is thus defined as the production of a perceptible, novel and useful product that is specific to the domain of the arts.

Accepting the system perspective on creativity (Csikszentmihalyi, 1999) and the socio-cultural approaches implies looking at creativity as consensual and negotiable. This means that there is no such phenomenon as creativity per se, but judgments about what and who is creative -and when and how this occurs- are socially negotiable on the basis of culturally shared understanding, knowledge and values.
According to Glaveanu (2014) “our cultural experience in the world is thus defined by interactions with other people and the use of tools and signs, regulating our actions. In this sense, the person never thinks or acts outside of this intricate and dynamic system of social, material and institutional relations that make up human society” (p. 21). How individuals negotiate and share their understanding of creativity at the point to reach consensus on definitions about practices and concepts has been investigated in several studies (Feldman, Csikszentmihalyi & Gardner, 1994). However, distributed creativity takes these perspectives further, conceptualizing creativity as a process where individuals jointly participate in the creation of new and valuable products, processes or ideas. This can happen in synchronous (here and now) or asynchronous (far away in time and space) trajectories, but the very ontology of creativity shifts from being individual-based to being collective-based.

According to Glaveanu (2014), the first traces of the concept of distribution applied to creativity are to be found in Miettinen (2006) and Sawyer and DeZutter (2009). Before these contributions, the concept of distributed learning was making its way in the field of technology-enhanced learning environments (Lea & Nicoll, 2002). The technological possibility of connecting distant learners and of disseminating knowledge in global dimensions brought about the need to rethink education, learning and cognition as distributed in space and time. When creativity studies applied the distributed perspectives to the relational views on creativity, the concept of distributed creativity began to be a reality. Sawyer and DeZutter (2009) tell the story of distributed creativity and its development as a conceptual change from the past. According to the two scholars, creativity studies have gone through a shift that is similar to that experienced by cognitive science during the 1980s and 1990s: “a shift away from focusing on internal mental states and processes, to an analysis of how cognition is distributed across people, tools, and environments” (Sawyer & DeZutter, 2009, p. 81). Learning and knowing move from being understood as essentially individual, brain-initiated and cognitive, to being looked at as participative, culturally shared and distributed amongst individuals. Sharing cultural practices and social interactions becomes central to the individual’s learning strategies and creative activities. Sawyer and DeZutter (2009) “use the term distributed creativity to refer to situations where collaborating groups of individuals collectively generate a shared creative product. Distributed creativity ranges from relatively predictable and constrained, to relatively unpredictable and unconstrained” (p. 82). The two scholars then focus on the latter form, the relatively unconstrained, which might generate unexpected creative results, and use the term collaborative emergence to refer to these group processes. This chapter will focus instead on formalized, constrained or semi-constrained settings, against the background of what artists retrospectively narrate regarding their working habits and compositional strategies. Since the author’s respondents are professional artists who are experts in all sorts of artistic modalities, this chapter does not look necessarily at collaborative art forms. Surprisingly, even art forms that tend to be more introspective and solitary, such as writing, turn out to be the product of distributed processes. However, the complex dynamics of how individuals create together and solve creative problems collectively is still to be fully described and explained. Sawyer and DeZutter (2009) point out “when groups of individuals work together to generate a collective creative product, the interactions among group members often become a more substantial source of creativity than the inner mental processes of any one participating individual. This becomes increasingly likely as the degree of contingency increases—as the dependency of each participant’s action on the preceding sequence of actions increases, and as it becomes increasingly difficult to predict an individual’s actions using individual factors such as personality traits or cognitive models” (p. 83). The specific characteristics of distributed creativity seem to be consistent for a wide range of groups and in a wide range of creative tasks. However, Sawyer and DeZutter (2009) seem to bemoan the lack of a wider variety of
research settings, most of these studies occurring in brainstorming settings. So this chapter will look at the creative process in the arts in its complexity, not limiting its analysis to brainstorming techniques, although focusing on the task of solving artistic problems. Moreover, the distribution implied in artistic creativity will be addressed as a sustained dialogue among individuals and across historical periods and cultures, as in Glaveanu (2014): “the production of what is creative is distributed both between people and across time” (p. 25).

With the above conceptualizations in mind, the author wishes to propose the idea of a distributed process of problem-solving. Creative strategies imply the stages of finding, defining and solving problems. Looking at how creative individuals manage these strategies (John-Steiner, 2000) shows that ideas about creative problems are distributed among individuals and across domains. When creative individuals solve problems, they engage in active conversations that are distributed in space and in time. Even when problems are apparently formulated or solved by a single individual, what the creative process behind the creative solution shows is a collaborative and distributed dimension, to the extent of being able to imagine the problem-solving stage as collaborative and distributed. This chapter will bring some examples of distributed problem-solving from the domain of the arts.

“YOU ARE ALWAYS IN DIALOGUE WITH SOMEONE”

According to the artists interviewed, the relational essence of their work is almost a psycho-emotional state. This participatory way of being and feeling is fundamental to the artists’ work regarding the artistic modality used. Even artists that tend to solve problems alone define their creative processes as collaborative. Among the artists interviewed, the relationship to and with others is exemplified in basically two metaphors: dialogue or fight. Similarly, some artists attribute to their relationship with models and masters a hard or a soft property: stealing or borrowing. To what extent the conflictual or more dialogical interpretations are due to gender is difficult to say. The fact remains that the fight-and-struggle metaphor is conveyed by two men, writer Morten Ramsland and theatre director Eugenio Barba (from now on, unreferenced quotes from conversations with artists will always be taken from the original narratives), while the dialogue metaphor is expressed by women (actress Julia Varley and writer Siri Hustvedt). Barba (2010), especially, often recurs to images of killing or burning down. However, as Siri Hustvedt suggests in her interview, the encounter with models and recipients can be seen in a gentler light. She quotes American critic Harold Bloom, author of *The Anxiety of Influence* (1997) and his Oedipal interpretation of the relationship between younger and older writers. Hustvedt acknowledges that, according to many critical approaches to literature, the younger writer seems to aim at *killing the father*, at getting rid of the influence that has been most formative for him. This turns the history of literature into the history of agonistic and often masculine competitions: “It’s all about fathers and sons” (Hustvedt). As an alternative to this view, Hustvedt proposes a feminine, less conflictual perspective: “I happen to think there are also literary mothers and aunts and grandmothers, and that it is possible to think about influence in a far less combative way. […] No doubt there are male writers who have had to overcome literary fathers, but not all writing is about killing the father” (Hustvedt in Chemi, Jensen & Hersted, 2015, p. 99). In other words, inspiring relationships can be less threatening than the father-like figure and rather be artistic “mothers and aunts and grandmothers” (Hustvedt) that hold the artist’s hands while she takes her first steps.
The fight and dialogue metaphors are two sides of the same phenomenon: the artists’ internalization of the work of other artists, someone they admire and try (or have tried in their youth) to imitate. The images of artists fighting or conversing imply different intensities of the same processes of internalization, through which they grow aware of their own voice and find their own artistic style. This dialogue/fight metaphor draws a picture of the artist looking both inside (his or her own practice, voice, style) and outside (his or her own models, inspirations, masters, recipients, significant others, collaborators). According to visual artist Michael Kvium, it is probably naive to think that artists are all alone when they create, “because your colleagues are with you inside the workshop all the time anyway, because you see what they are doing, they are part of your reality”. So, the dialogue does not stop when the artist is physically alone in the workshop or the studio, because he brings his knowledge of others’ work with him.

By looking at artistic practices, this chapter points to several dimensions of dialogic interaction. When artists solve artistic problems they engage in a simultaneous dialogue with:

- Themselves: Who they are, who they imagine themselves to be, who they envision they will (or wish to) become, who they have been.
- Others (colleagues, significant others, masters, benefactors).
- Audiences / recipients.
- Medium and artifacts.

The following sections will elaborate this claim with concrete examples of artistic practices and artists’ statements.

ARTISTIC IDENTITY: IN DIALOGUE WITH YOURSELF

Preparing for artistic practices starts long before the artist meets artistic challenges in a specific medium and in a given situation. The artists interviewed tell stories of their first meeting with an artistic experience that left a mark in their life and their stories are vivid and crystallized memories of transformative experiences, descriptions of which are coherent with the concept of transformative learning (Illeris, 2009; Mezirow 2000, 2009). These memories are still extremely present in their minds and the transformative quality is clearly perceptible. The experiences were sudden, personal and meaningful, new to the artist in a given context. They were not completely conscious or explicable, spurred to action, felt as if they were happening at “the right time” and encouraged persistence (Chemi, Jensen & Hersted, 2015). The consequence of going through this transformation is that the artist moves from a situation in which some kind of interest or disposition is frustrated by some sort of disjuncture (writer Morten Ramsland, for instance, was unappreciated at school because his writings were too imaginative) to a situation where a specific artistic interest flourishes. This transformation connects the self with a specific artistic profession, adding to the artist’s identity.

This step in the artists’ life is fundamental to their subsequent life choices and influences their commitment to the creative project. When artists are able to claim, “I am an artist” their attitude towards creative strategies changes radically, because the creative drive is not something to be waited for or wished for. From the moment in which the artist decides to be an artist, then inspiration, tools, ideas and challenges can be pursued systematically. This can only be done by means of an explicit commitment and will. Opera singer Marco Nisticò, in recounting his artistic development, gave in to what he
might have been fighting against (in his case, family expectations of him becoming an opera singer) and engaged in his creative, life-long journey.

It is the author’s belief that, in dialogue with themselves, artists have one central focus of attention: what are the most appropriate ways of learning and creating for them and, subsequently, how to provide solutions to creative problems in their given contexts of work. This seems to be something to which artists give a great deal of thought and end up by being quite aware of. When interviewed about their creative strategies, and after gently protesting against the effort of defining something difficult to put into words (creativity), the artists show a deep-seated knowledge and awareness about the strategies that work optimally for them in their case. They seem to be in touch with the learning and creative strategies that best can support their working style. Most of all, they seem to be aware of themselves as learners and creators in relationships with others and with chosen media. As the section below will suggest, this is fundamental to the specific way in which artists solve problems.

RELATIONSHIPS WITH OTHERS: A DIALOGUE WITH PEERS

Artists, in claiming never to be alone when they are creating, also mention a variety of relationships that either help and inspire or trouble and challenge them.

Significant others can concretely inspire artists, closely or at a distance, with ideas, resources, experiences, challenges or artifacts. A friend might present the artist with a life-changing book, as for instance in the case of Ramsland. A family member may invite the artist as a child to build a nativity display, as in the case of film-maker Mary Jordan. Entire families may perform, make and consume music, as in the case of musicians Anders and Benjamin Koppel or Marco Nisticò. It could also be the case of a more experienced person, a master or a role model. Sometimes, however, relationships run through asynchronous trajectories where they unfold through time and space. In this case, the master could be someone from the past that the artist admires, as in the case of Hustvedt and her admiration for Dickens. Or it could be a collective of individuals, as in the case of Barba, whose source of inspiration is the religious rituals in the Catholic Church. Here it may be helpful to distinguish between collaborative interaction, when artists share and shape together, and a distributed perspective, where the relationship between individuals can be asynchronous (artists do not actually operate in the same time and space) and not necessarily based on group work.

When the interaction with others becomes more concrete, it is often specifically focused on the production of art. Significant others might help to shape the process with feedback at the right time and in the right way, or with materials brought in collaboratively, as for the performing arts but also for design and architecture. Even though the ownership of the work of art belongs to the artist, many individuals contribute to the actual making of art. Artists seeking feedback throughout their creative processes open up their workshops to others and engage with them in a special kind of participatory problem-solving. In the end, it is the artists’ responsibility to take the appropriate decisions in order to translate into artistic forms what they are envisioning, but in the meantime the feedback from others has contributed to finding the right solution or discarding the solutions that do not work. But feedback in artistic processes is a very sensitive matter and some artists (Ramsland, Hustvedt, Varley) raise a specific problem – the fact that sharing works of art with others can be inappropriate if this happens too early in the process of making.
Visual artist Michael Kvium defines it as a sort of shyness or modesty in throwing oneself into such a task where one is actually exposed as an individual, because artists put something of themselves in the work and this can be “a very fragile construction”. Works of art should not be shared too early, they are fragile (Ramsland) and their makers are “sensitive about their own work” (Hustvedt). Therefore, they not only carefully choose who is going to give them feedback amongst their most trusted peers, but also they choose the timing for this to happen in the most giving way. Kvium describes the paradox implicit in the dialogues with critiques, either inner criticism, or fictive or even real critics, and he discusses what is dangerous during the creative process: vanity and too much appreciation. If artists choose to get criticism from someone who is too much like themselves or too positively affected by the work of art, then they will miss out on the necessary resistance, in order to challenge solutions and achieve learning. On the other hand, feedback or experiences that are too challenging might be counterproductive. This is perhaps the case of relationships that are felt and reported as challenging or conflictual. Even though artists tend to expose themselves to diversity and a variety of experiences in order to get inspiration and ideas to solutions or knowledge, they always situate the work of art’s need in a context. Diversity and cultural meetings are productive as long as they provide solutions to the given problem, the artistic challenge defined by the artist’s vision, ambition, chosen medium, recipients, culture, domain of expertise, field of peers and support provided by others.

Engaging in collaborative partnerships is a challenging practice where the individuals actually expose something of themselves. Collaborating and participating in each other’s creations can be very fragile structures, because artists must dare to open up their own closed universe for another artist and must make judgments on how much to dare or to get involved. According to visual artist Michael Kvium, who is often engaged in collaborating with other artists, to share one’s own work comes with a number of dilemmas, such as being afraid to pollute one’s own work with the other’s ideas. One can also be afraid to give too much of oneself, so it feels like losing something or one is unsure as to how much to invest in a given project. He also believes that in participatory works it is important to have some common points and to be curious about each other. If these common grounds can be established, then collaborative practices can also be emotionally liberating, because the individual does not actually bear the full responsibility alone. The joint effort might feel slightly more relaxed than the individual work: “you should not bear the burden alone” (Kvium).

One of the fundamental roles that others can have in the development of creative works does not emerge in the interviews from this study but is addressed by Moran (2010): financial support from the field. Moran makes the point that society plays a fundamental role in creativity as much as creativity plays a fundamental role in society. She suggests that, in general, society interacts with creative enterprises mainly through the work and influence of benefactors, regulators and consumers. This can be applied to the production of art, where gatekeepers can sustain artistic projects financially by providing or allocating resources or by evaluating the creative level and content. The latter is touched on in the interviews with the artists under the theme of recognition. Experts from the field and recipients can often decide the success (or not) of a single work of art or artist, or more in general of a creative product, process or person. Artists are aware that the field of peers or society can guide the creative process at a distance. They react differently, either accepting the fact that attention-seeking can disturb the creative process or suspending their awareness of audiences.
RECOGNITION: A DIALOGUE WITH RECIPIENTS

During the slow and careful sedimentation required by artistic creativity, recipients are present in several forms. Artists express it differently: from the indistinct “someone” (Nisticò, Nord) to more detailed descriptions, where artists tell that, when solving artistic problems, they often talk to an audience (The Mira Quartet, Benjamin Koppel: “there is no music without audience”) that gives the work of art more meaning (Valeur). Film director Annette K. Olesen says that the artist’s work basically consists in telling stories to an audience, while other artists in other situations might want to engage in a conversation with themselves or with society at large. The most important point is that the process of creation needs both the presence of recipients and their absence. Clear signs of an ambivalent relationship with recipients show that, on the one hand, artists need their presence but, on the other, they need to establish the recipients’ induced absence. The artists interviewed include recipients in their artistic project, no matter how wide or narrow the audience involvement, as Barba’s “most refined artistic experiment for only 20 spectators” confirms. At the same time, they must suspend their awareness of composing for a recipient if they want to be free of critical judgment. Ramsland writes and visual artist Julie Nord draws as if recipients were not there. This means that, while composing, artists try to suspend issues of reception or recognition as much as possible. Benjamin Koppel says that jazz musicians focus on their instrument and what comes out of it. They carefully listen to their instrument and not only to what they envision the final result should be. They concentrate on what is here and now - the dialogue with the medium and with an ideal recipient. Attention to the final product, to its actual reception and even issues of public recognition are put on stand-by. Hustvedt tries not to walk the “slippery slope of recognition” and Anders Koppel mentions the anxiety that recognition can give to a performer: “the same applies to rehearsals. If you only see yourself at Carnegie Hall next week, playing there […] then everything goes completely into spasms”. In her study on writers, Perry finds that they are able to manipulate the presence of the reader in the creative process, inviting real or fictive readers into their creative flow when the timing is appropriate (2005, p. 34).

Once again, as in the case of significant others who help or challenge the artistic creation, recipients can influence the creative process either by means of their physical presence or induced absence, but also by means of asynchronous relationships. In other words, when recipients are not here and now in dialogue with the artist or the work of art, the dialogue can be defined as asynchronous and distributed in time and space. An example of the latter is the ideal recipient or the ideal master for whom the artist internalizes and composes.

MATERIAL MATTER: DIALOGUE WITH MEDIA AND MATERIALS

In creative processes, one last dialogic relationship is established with the work of art, that is, with the medium or artistic modality chosen for the task at hand. Artists reporting on their compositional processes formulate to themselves very concrete tasks, rules and problems to solve, all relative to the medium they have chosen. Matter and artifacts are so much present in the artists’ narratives as to be one of the elements of the distributed dimension of creativity. Taylor and Statler (2014) emphasize some of the background considerations that artists might have in mind when solving creative problems. Drawing from the tradition of Expressive Arts Therapy, these authors point to the quality and functions that materials bring to the artistic dialogue. For instance, fluid materials seem to elicit more emotional
processes, as opposed to resistive matter, which seems to generate more rational reflections. According to this perspective, artists might engage in judgments on matter and make artistic choices accordingly. Ambiguity of form, material boundaries, quantity, kinesthesia and sensory awareness are all intrinsic elements of the dialogue with the artistic medium. Even mediators (Taylor & Statler, 2014, p. 598), such as paintbrushes, scripts or clay knives, influence the creative process with a mediation that seems to enhance a reflective distance, which impacts the creative problem-solving.

Artists struggle against the very limitations of the medium. According to Kvium, artists take up the human being’s universal struggle between unlimited ideas and material limitations and make it tangible through materials (colors, sounds, movements, shapes) and media (words, digital signs, music, spaces). This struggle/dialogue is so vivid that artistic materials have a fundamental role of agency in the process of making artistic choices that are appropriate to the task at hand. An example of creative practices that acknowledge media and materials as a dialogic counterpart might be the artist’s need to prepare the artistic space before creation. Kvium, for instance, describes a basic need to initiate his painting sessions with the routine of cleaning the brushes. Even though this might be seen as a trivial task that assistants could take care of, the artist needs this preparation stage, made of bodily engagement with matter. Touching the brushes, feeling their thickness, their weight, their shape and balancing them in one’s hand induce the sensory awareness that prepares the artist for creation. In a similar way, theatre director Eugenio Barba sweeps the theatre space before rehearsals or workshops in a sort of ritual that shifts from the ordinary to the extraordinary of artistic spaces. Once artistic spaces are established, materials and matter become active partners, acting and reacting to the artists’ trials.

**SOLVING (AND FINDING) PROBLEMS WITH OTHERS**

Unlike laypersons, who are not necessarily expected to work creatively in their profession, artists engage in creative processes with a strong sense of agency. Unlike laypersons that suddenly have to engage in a creative task without being trained in the continuous practice of creation, artists are not concerned with or interested in the stage of idea-generation. Not one of the artists interviewed mentioned idea-generation as part of their compositional process. On the contrary, they stressed the fact that ideas are already there, somewhere in their head (writer Siri Hustvedt’s “talking head” or opera singer Marco Nisticò’s “singing in your head” or painter Julie Nord’s “seeing” or “listening in your head”), in their body (actress Julia Varley) and in their everyday or professional life (in the process of making for dancer and choreographer Palle Granhøj and theatre director Eugenio Barba). For professional artists, the task of getting ideas seems to be relatively simple. The reason for this might not reside in biological, genetic or divine reasons. In other words, this might not happen because these individuals are biologically or genetically talented (the myth of genius) or because of heavenly inspiration (the myth of the Muses). It may instead be due to long-term and voluntary commitment to the task of artistic creation. In doing so, artists systematically and purposely provide themselves with the best conditions for storing inspiration and ideas in a sort of idea reservoir and then for listening to the best ideas amongst those collected. So, the first problem to be solved in artistic creation seems to be the effort of feeding the idea reservoir with multiple inspirational sources.

Artists solve this problem collaboratively by intentionally exposing themselves to a large variety of experiences that are meaningful, stimulating, encouraging and diverse. This idea is supported by creativity studies that look at creativity as the emergence of insight from subconscious or internalized
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dynamics (Sawyer, 2003, p. 21). Sawyer cites Simonton’s cognitive model as an example of internalization of mental elements that are stored in the brain and released appropriately into combinations of “chance configurations” (Sawyer, 2003, p. 21). Even though this strategy might seem to be functioning at psycho-emotional and individual level, looking closely at what artists mention as inspirational sources, the distributed dimension becomes clear. Artists mention meetings and interactive experiences as being most powerful and transformative: the meeting with a significant other who opens the doors to a new world (Varley, Ramsland) or a meeting mediated through artifacts (a book to read, stilts to walk with, a Nativity display, a religious ritual) or through more intangible feelings of admiration as for Palle Granhøj and Julia Varley, who were fascinated by other artists’ viewpoints that were novel or provocative. Other inspirational experiences might emerge in contact with nature, during cultural meetings or travels, or also in everyday negotiations with family and children. What all these examples have in common is the fact that they are based on relationships with other human beings, either real individuals in the artists’ lives or role models to admire though their artistic work. Even the meeting with nature seems to be mediated in the subject’s meaningfulness and aesthetic value. Another characteristic is that the source of inspiration is never a single, but a multiple solution. Studies on creativity identifying only one way of generating creative behavior are destined to be contradicted by other studies proposing other solutions. The creative reality is that the idea reservoir builds on multiple choices and stimuli. Last but not least, artists develop a distinctive sensitivity to the habit of collecting ideas, regardless of whether they might use them immediately or not. Inspirational experiences turn into a steady mind-set or disposition toward the search for inspirational experiences, individuals, environments or artifacts: a consistent and sustained over-stimulation of senses, aesthetic perception, intelligence and knowledge. This habit seems to emerge as a systematic strategy as soon as the artist achieves a professional self-consciousness about being (or wanting to be) an artist. When the artists’ identity is self-defined, then one of the solutions to the problem of idea-generation and art-making consists in building up to a greater awareness about one’s own learning needs: where do I have to seek inspiration for this work? Who do I need to meet? Which experiences do I need to have? Voluntary exposure to inspirational and often serendipitous experiences brings fuel to the creative reservoir.

Once the idea reservoir is well stocked, the second problem is to find the best environment for these ideas to be listened to, to flourish and to come to life in the different art forms or media. Ideas are something one has and that do not need to occupy too much space in the artists’ awareness of the compositional process. The artists’ effort is rather focused on shaping their ideas; what artists strive to find is form and solutions or new problems and experiments. The emergence of ideas has a direct consequence for compositional craft: the drive to apply hard work, craft and skills, concentration or intensity of concentration, experimentation, memory, flow or group flow to the art-making process.

Solving different problems according to different stages or learning to accept and navigate through chaos is the core of participatory problem-solving. French mathematician Henri Poincaré described his creative processes as consisting of the stages of preparation, incubation, eureka and verification (Weisberg, 1993). Partly, this is also what the artists interviewed for this study describe, except for an essential difference: rather than describing successive stages happening in a fixed order, they seem to describe these stages as simultaneous elements of the creative process. In her book on artistic collaboration, Vera John-Steiner (2000) finds historical evidence for the participatory, distributed and emotional dimensions of creativity across different domains, different cultures and across generations and genders. The narratives of the artists interviewed seem to corroborate her findings. Of course, some artists emphasize that working styles can be very different for each individual, but they all seem to be aware of working
styles and mindful of their own disposition. For instance, writer Morten Ramsland specifies that there can be a huge difference in how each writer works and that there is more than one way to go about it. He cites his own creative style as an example of an approach that is very intuitive at the beginning and very structured at the end, whereas other authors can be really structured from beginning to end, thinking through the novel and having it all sorted out before engaging in the actual writing. As an example of the latter he mentions his friend and fellow writer, Christian Haun, and American writer John Irving. In Ramsland’s account the two writing strategies are very dissimilar and they seem to challenge the artist with very different problems: the former allows the novel to be made while it is being written, the latter requires spending several months thinking and planning, only writing notes and working on characters conceptually. In the former, the artist does not possess a specific, fixed overview of the novel’s structure. He needs to write his way into it. In the latter, the writing process starts when the novel has already taken shape in the writer’s head (and body), so the writing process consists to a great degree in feeding the envisioned novel with material, which has already been created in the mind. Ramsland is even more specific about his creative process and tells that his working style includes the possibility of going away, of being alone, of closing the door, of switching off the phone, because from time to time he needs to dance around and shout and to enjoy music or painting, as a break from writing. This description of his creative strategies might paint the portrait of an artist isolated in his studio, yet he brings his colleagues with him in a sort of distant conversation (Haun, Irving) or in the form of music as fuel for his very intuitive and sensory approach to writing.

When artists work collaboratively, they might explain their relationship in metaphors of families (Odin Teatret), homes or marriage. Members of the Mira Quartet feel almost as if they were married. Sometimes they just cannot take the tension, and at that point “you need to say something, even though you wish to be good friends all the time” (Signe, Mira Quartet). They say that the problem of relational conflicts has its solution in clear communication, life experiences and compromising. Members of collaborating teams should always be aware of the consequences of outbreaks that might, for instance, result in the group falling apart and musicians not being able to play together anymore. Solving logistic challenges is done by means of compromises. For example, the members of the quartet live in two towns, about 100 km apart from each other. They have decided to meet half the time in one city and the other half in the other one. A similar kind of compromise is found in the strategy of architects Johannes and Inger Exner. These two architects, partners in life and work for more than 50 years, incorporated an unspoken routine into their everyday life that allowed them to work collaboratively and from time to time to have individual space. Their studios were *en suite*, only divided by a double door. The tacit agreement was that when the door was closed one of them needed undisturbed time alone.

Agreeing on these logistic rules demands skills in communication, which for artists is not only necessarily verbal and explicit. Communication, for the Mira Quartet, is a sort of telepathy, unspoken communication where “you don’t need to make agreements on everything” (Birgitte, Mira Quartet). Indeed they say that they concentrate on each other during performances, as a sort of reciprocal inspiration and focus-keeping. Of course, in order to develop tacit agreements members of the ensemble need to know each other very well and know each other’s reactions, share common values, and a common sense of purpose: “you must want the same” (Signe, Mira Quartet). If these conditions are active, the members of the ensemble might perceive each other as a unity and an organism, and end up experiencing group flow (Van Hout, van der Borgh & Weggemman, 2016), clear in the Mira Quartet routines: “we can spend half an hour or an hour on three strokes, without any of us thinking, now I would rather have coffee”
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The common feeling of absorption and self-forgetfulness is shared in the group and contributes to the well-being of its members and to the task at hand.

Sometimes the artist’s chosen values influence more practical and logistic choices, with specific consequences. Architects Exner did not wish a large organization with a heavy bureaucracy, so the number of collaborators was fixed as the number of passengers that could fit into a Volkswagen. In such an organization, understanding each other is easier, as is developing a common collaboration rhythm and a respectful communication tone. The Exners emphasize that in small organizations novices and experts are not far from each other and can share knowledge and experiences. Like them, choreographer Palle Granhøj points to the many benefits of being a small organization. For these artists, the main benefit is that the principal, inspirational leader, who is often the most experienced, can easily and effectively provide motivation, knowledge, inspiration, challenges, structures and rules for the less experienced colleagues.

DISTRIBUTED LEADERSHIP

When artists collaborate, as in any collaborative task, leadership is a central negotiation of meaning, working forms and creative tasks. Leadership can be a critical element in collaborating groups, and artistic ensembles or partnerships are no exception. The artists interviewed, especially those who actively engage in collaboration or work in ensembles, such as the Mira Quartet, acknowledge this challenge. Different artistic traditions solve the leadership problem differently. For instance, in the tradition of string quartets, leadership happens by taking turns. This tradition is apparently strictly codified in chamber music, a codification primarily initiated in Germany and Austria, where the primarius leads and the others follow (Blum, 1987). The role of primarius is not permanent for one single individual, but when the role shifts, the whole group needs to adapt to the changes. Followers are as important as the lead and they almost depend on each other. This pattern repeats itself even in ensembles with clear and agreed-upon leadership, like Odin Teatret or Granhøj Dans. In both ensembles the leader (Eugenio Barba for the theatre group and Palle Granhøj for the dance group) gets ideas and leads the montage of the performance. But the performers create materials, get inspired by the leader, learn from each other and give back to the leader as much knowledge, inspiration and actual materials for the performance as they receive. The distinction of creating artist and performer that Granhøj mentions in his interview is in reality a matter of timing and contextual roles in relationships with others, more than an ontological or psychological character trait of the single individual. In other words, the artist’s role in the collective (or broadly participatory) process is defined by the concrete artistic challenges that the group negotiates mutually, rather than being due to the artist’s set personality.

The practice of shared leadership is also mentioned in the Exners’ interview. Here the two architects tell of a very fine line between the creative and organizational leadership that they shared. Even though Johannes had a more specific focus on the generative parts of the process and Inger was more in charge of the organizational part, they found real difficulty in separating the two areas of expertise. This might be due to the fact that the creative and administrative part of the creative process are so closely interconnected that it is, in general, impossible to separate them. Also, the two architects, like the performance artists above, used to shift their roles flexibly according to the task at hand.

With the above in mind, descriptions of how artists solve creative problems acquire a different light. Dancer and choreographer Palle Granhøj describes his creative process as a chain of subsequent challenges that are nourished by dialogues with others. At the core of his (and his ensemble’s) creative
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process he places the ability to find, react to and redefine given rules. In terms of problem-solving, this can be translated into the following:

- **Rule-Finding → Problem-Finding**: The capacity of, readiness and sensitivity towards finding problems to solve. These problems are generative, open and motivating.
- **Rule-Reacting → Problem-Solving**: The capacity of, readiness and sensitivity towards finding solutions to creative problems.
- **Rule-Challenging → Redefinition of Problem**: Artistic practices happen not only to find out-of-the-box solutions but often challenge the very box where creation is happening. When this occurs, a re-definition of the creative problem might be a consequence, as well as a re-definition of tasks, roles and visions.

At the end of the day, it is the artistic leader who decides what works for the task at hand. But his colleagues bring to the process the problems they have found and the solutions they envision, while perhaps obliging the leader to redefine problems and tasks.

A similar dynamic is to be found in artists that do not work in ensembles but open their work to the participation of others. Writers, for instance, who often work alone, open their writing workshop to chosen individuals, at chosen times, with clear needs in mind.

Writer Morten Ramsland points out how sensitive it is for him as a writer to share the early versions of his work with others. Even though he carefully chooses peers or significant others to give him feedback, he believes that the early versions of his work cannot (and should not) see the light too early, “just like kittens”. In his opinion, artists have a developed sensitivity to timing in the creative process and this is part of the ways in which they solve creative problems involving others. Outsiders should not be involved in the process of finding solutions for the artwork before the artwork itself can bear critique and feedback. Artists develop intuitions and awareness about the right timing in which feedback and critique would be more relevant to their process. Secondly they hold on to the significant others that give them critique. This could be an editor for writers, or scholars in the artistic discipline practiced (as does Odin Teatret that collaborates with performance studies scholars), or colleagues, but also friends, partners and family members. In some cases, roles overlap, as in the case of American writer Siri Hustvedt, who is married to fellow writer Paul Auster, with whom she has established mutual trust in reading each other’s works.

According to Ramsland’s experience, the ways in which individuals give feedback is very different. Some just say what they think, others engage the writer in an active dialogue (“I talk with them and sometimes, I put down a lot of stuff in the manuscripts and sometimes nothing and just say something afterwards”). Pride, inflexibility, distrust and lack of timing can annihilate the generative effect of feedback.

Feedback giving and taking exploits what for writer Siri Hustvedt is intrinsic in the nature of art itself, which is dialogue. In this practice, the generative artist acts as leader of her project, inviting into the process someone she trusts, someone who believes in the project, and she feels comfortable with, someone who ends up participating in her work of art in a distributed perspective.

**HIGHER EDUCATION AND ARTISTS**

According to Weisberg (1993) the need for training in creative techniques has generated a whole “creativity training industry” (p. 58) that promises to produce more creative workers and therefore more
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creative products and therefore more revenue. Industry has been attentive to developments in the field of creativity studies and contributions in this direction often focus on creative problem-solving techniques (see Weisberg, 1993) and on the idea-generation stage. Examples of this are brainstorming (Osborn, 1953), the six thinking hats (de Bono, 1985) and the vast quantity of creativity consultancy offers on the market. According to McFadzean (1998), creative problem-solving techniques are many and can be classified according to their degree of disruptiveness. In other words, even though these techniques are diverse, they can be grouped into paradigm preserving, paradigm stretching and paradigm breaking, depending on their effect on individuals and organizations. This chapter will not attempt to review all sorts of creative problem-solving techniques, but rather to emphasize that often these techniques seem to be used in private or public companies exclusively to get help with idea-generation tasks. Surprisingly, professional artists almost ignore the stage of idea-generation that seems to be so essential to the problem-solving industry. In the former model of problem-solving, education for creativity should focus on idea-generation. Artistic idea-generation is a direct consequence of broader strategies of collection of inspirational experiences, exposure to diversity, self-awareness about optimal learning and working processes. Can the latter technique be learned and taught? Different educational approaches might answer differently. In a problem-based educational perspective, several approaches to creativity can be envisioned. For instance, if artistic creativity were to inspire new ways of training creative problem-solving in adult and higher education, what would it look like? Having learned how artists describe their compositional, participatory and learning strategies, what novel approaches to higher education might be envisioned?

First of all, a fundamental distinction must be made. When creative approaches are needed or desired in educational environments, what tends to lead the process of thinking about learning and designing educational tools are specific learning ideals, values and attitudes. These ideals are often of pragmatic, constructivist and socio-cultural nature. Creativity becomes a need when learning is looked upon as the experiential and critical development of individuals in relationship with others. Learning itself is then interpreted as an essentially creative enterprise: experiences with real life-problems trigger a process of inquiry, which is a fundamentally experimental process. Inquiry is based on the generation of ideas, the formulation of hypotheses and research questions, the acquisition of knowledge about concepts and theories. Learning occurs in potentially innovative processes, where students take charge of their own learning, think critically, acquire knowledge in action, and learn by means of trial-and-error processes. The educational designs that often offer opportunities for learners to actively participate in their own learning in creative, effective and engaging ways can be problem-, project- and group-based (Kolmos, Fink & Krogh, 2004). These collaborative educational environments design opportunities for the students to find, formulate and solve problems that they find relevant, engaging and inspiring. But how can educators optimally support these processes? My conclusive suggestion is to look at the artists’ creative and learning processes.

Concentration, inspiration and finding problems are some of the frequent elements that artists describe as necessary to the creation of artworks. Can they be induced and learned? Can educators and students learn from artists at all? Are educational structures too tight for experimentation, even in constructivist-inspired settings? Going through what the interviewed artists narrate above, it is possible to find inspirational sources for implementing creative change in higher education.

Applying the artists’ narratives and biographies in educational and developmental settings, an innovative educational model might emerge. What can be learned from artists is this: creativity does not happen in a void, but in and by means of relationships; creativity does not occur by chance or suddenly, but is a process that requires commitment and long-term hard work. Acknowledging this truth about
Distributed Problem-Solving

creative practices in education might have the consequence of allowing for long-term engagements with given topics, in the attempt to acquire both content expertise but also methodological skills. Moreover, the distributed or collaborative elements would be looked at differently. Collaborating groups are not just the configuration of several individuals but a working community that shares common interests and whose members participate in a variety of ways in the shared project. In this way, solving problems with a distributed perspective might release the individual from the group pressure of having to perform equally. When individuals participate in a common project, they do it by means of what they can (skills, knowledge, disposition), what they wish (purpose and ambition in the given project) and what they envision (the change they aim to achieve). Groups, teams and ensembles are constituted by the ever-changing composition of various individuals’ skills, drives and commitments, which change according to the individuals’ mutual relationships, the nature of the project and the individuals’ life circumstances. Acknowledging this diversity and preparing the students to cope with this complex, multiple and flexible reality would be essential for managing creative projects.

Artists cope with complexity by looking at the inspirational potential of diverse sources. The strategies that artists use in order to supply their ideas reservoir can be of good use in higher education. Students that are expected to think critically and creatively cannot be taught only theoretically or conceptually, they need (as learners in general, Dewey would claim) the experience of navigating though complexity and getting inspired in the process. So the first step would be a perspective shift: from looking at complexity as a negative phenomenon to exploiting the inspirational opportunities in a complex environment. The second step to achieve for educators would be to design complex, diverse learning environments that stimulate and inspire students, but also to implement skills and dispositions (e.g. critical thinking, associations, observation tools, paradoxes). Metaphors can be useful core concepts. Collaborating groups or individuals inspiring each other often find metaphors that describe their shared visions or that define their relationship to their members and to external recipients. Metaphors are dense with meaning and higher education students need to exploit and to play with them creatively.

The benefits of collaborative work or of the participatory mind-set are not only logistical (the work-load is shared with others) but can also be psycho-emotional. As some of the artists state above, a joint effort can feel slightly more relaxed than individual work. As the work-load is shared, so is its responsibility. Emphasizing the emotional benefits of collaborative and participatory practices can be beneficial in higher education and might lead to: the increase of problem-based or project-based educational designs; the students’ engagement in these practices; the educators’ renewed attention to training and stimulating students’ reflections on the emotional aspects of collaboration.

As analyzed above, the core of distributed problem-solving in the arts is the dialogue that occurs in the artists with themselves (who they are, who they imagine themselves to be, who they envision they will -or wish to- become, who they have been), with others (colleagues, significant others, masters, benefactors), with audiences or recipients and with the chosen medium and artifacts. Preparing students to solve problems while being engaged in such dialogues can be a challenge and a benefit for educators in higher education. First of all, the dialogue with oneself can be scaffolded by means of a variety of tools, such as portfolios, students’ reflections, logbooks and self-reflective exercises. However, adult individuals in educational settings might find these tools too ‘artsy’ and may fail to see their direct relevance for solving problems. It is the educators’ responsibility to develop and apply tools that can teach intrapersonal dialogue, but also to make their relevance clear to the students.

Educators ought to challenge their students in solving artistic problems, even if the arts are not their professional domain. Artistic problem-solving can be an area of training cognitive and emotional skills,
Distributed Problem-Solving

of building metaphors and of investigating media and materials. In doing so, the students engage in a
dialogue with cultural traditions and might get accustomed to thinking of problem-solving as participa-
tory and distributed.

Dialogue with others is, at least in the problem-based learning tradition (Kolmos, Fink & Krogh,
2004), what is most supported by educational and organizational literature. Communication, conflict
management, appreciative approaches and rhetorical tools are some examples of it. Distributed leader-
ship, however, can be challenging to negotiate and practice. In this field of studies, practices are still
needed in order to link artistic or arts-based methods to educational strategies. Part of the dialogue with
others, in the arts, is specifically directed to the recipients of a given work of art. In educational set-
tings, the recipient is often the teacher. Students put their effort into producing artifacts that begin and
end within the school environment. Traditions of experimental and experience-based education offer
an alternative to that. In higher education this can (and should) be systematically implemented in order
to stimulate the students’ creativity. Producing knowledge for a “real” audience, which is going to be
the final recipient and is going to be involved in the dissemination stage, can have positive impacts on
the students’ motivation. Like the artists above, students could be trained to consider their recipients in
their work, but at the same time could become able to suspend awareness of their end-user, in order to
find novel and valuable solutions.

Last but not least, higher education students might benefit from playful interactions with sensory
experiences involving materials, media and artifacts, as research in management education shows (Taylor
& Statler, 2014). This would extend the opportunities of thinking holistically and of finding unforeseen
solutions to unexpected needs and problems. By looking on materials and artifacts as active partners
in their learning conversations, students might shift their mind-set from problem-solving to distributed
problem-solving where materials and significant others participate actively in shaping the knowledge
and production process. In other words, educational practices that include cognitive, emotional and
bodily interactions with materials and artifacts might help students in higher education when the need
for creative problem-solving occurs.

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**KEY TERMS AND DEFINITIONS**

**Art:** Something that is man-made by means of skills and crafts, involving media, materials and meanings, and that is shared with and meaningful to others.

**Artistic Creativity:** The production of a perceptible, novel and useful product that is specific to the domain of the arts.

**Arts-Based:** What is based on artistic products or processes.

**Creativity:** The outcome of social negotiation occurring in given cultural spaces, by means of which perceptible products or processes are defined as novel and useful to and for someone.

**Distributed:** What is synchronously or asynchronously distributed across people, tools, and environments.

**Innovation:** The systematic creation of something novel and useful with an added value to someone.

**Learning:** A persistent capacity change by means of will and commitment.
Chapter 8
Creative Life Experience among Students in Medical Education

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ABSTRACT
This chapter mainly focuses on creativity and creative life experience of medical students in a university in China, in order to find out strategies of improving the medical students’ creativity. The methods such as literature review, participation, intervention, and questionnaire survey are used jointly in this study. The students are divided into experimental group and control group. A two-month creative psychological intervention is carried out with the experimental group, and the results show that the level of creative life experience factors of the experimental group was significantly higher than that of control group after the intervention, which indicates that appropriate creative psychological intervention has certain effect on improving university students’ creative life experience.

INTRODUCTION
The talent of new era should have the good quality that advancing with the times, such as system, coordinated, flexible use of various basic ways of thinking, especially the image thinking, divergent thinking and intuition thinking. The strong desire of creativity and flexible create psychological quality are also needed, such as competition consciousness and innovation ability, and the ability to withstand setbacks, etc.

The central committee of the communist party of China under the state council on deepening education reform and comprehensively promote quality education decision clearly pointed out that it should attach importance to cultivating students’ innovation ability, practice ability and entrepreneurial spirit in the higher education, should cultivate the students’ innovation spirit and practice ability as the key,

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and should cultivate the students’ scientific spirit and innovative thinking. However, the modern medical education is insufficient in China in cultivating medical students’ scientific research ability; caused most of the students don’t have a strong scientific research consciousness. It not only influences their comprehensive quality, but also limits their development to some extent.

Therefore, through the description of students’ creative life experience level in a medical university and exploration on method and theory of enhancing creativity, this study provided an appropriate intervention on college students to improve the students’ ability of innovation, and aimed to find out the strategies for the improvement. Thus, provides theoretical basis and practical experience for researches of improving the college students’ creativity in medical education environment.

BACKGROUND

Creativity Psychology: Definition and Characteristics

Creativity psychology refers to the creative factors people may exhibit in the process of cognitive process, emotional process and willed process, including the creative factors in people's needs, motivations, beliefs and personality, temperament, ability of psychological orientation and psychological characteristics. During the activities of creation, one may has his complex psychological structure, in which the creativity is the basic composition, and the creative thought is the core of the creative ability. Creativity psychology has five characteristics including the uniqueness and novelty, the divergent and flexibility, the logical, the subject of potential, and the risky. At the same time, “college students’ creative thinking has the development features, namely the depth of thought constantly increasing, the divergent thinking number constantly rising, and the independence, critical and initiative of thinking continuously improve” (Chen, 2008, p. 2-3).

Many theories of creativity are put forward, such as the three-dimensional intelligence structure theory (Guildford, 1991), which believes that there are two forms of thinking: convergent thinking and divergent thinking, and divergent thinking is the core of the creative thinking. Guildford (1991) defined creativity as the joint of a variety of abilities.

To gradually cultivate the medical students’ strong innovation consciousness and innovation ability to entrepreneurs, the following several aspects may be help in accordance with their main characteristics and performance: 1) strengthen ideological education work, provides the ideological basis for cultivating students’ creativity; 2) scientifically build the creativity psychology knowledge structure framework of college students; 3) designing evaluation methods for their learning evaluation; 4) strengthen the practice teaching and focus on the cultivation of students’ creative ability; 5) develop the personality of college students and respect their interests; 6) creating an innovative ability training and educational environment; 7) strengthen the basic construction of teaching and research.

Studies on Creative Life Experience

Psychologists take the creativity of human culture and civilization as the big Creativity (big C), and that of everyday life experience small creativity (small C). Psychologists not only focus on creativity in the special abilities (such as art, science, etc.), but also pay attention to how the general person shows unique creative life experience. Professor Wu Jing-ji (1988) thinks everyone is full of experiences of
solving problems in life, sometimes by small ideas can defuse the crisis. Innovation may not be invention, sometimes is the sort of small creativity to solve problems. Such as marketing ideas, to do the existing product packaging and application of the new ideas is a kind of small C. So, an important research direction of creativity is how to motivate the individual to apply creative ideas into practices of problem solving, and make life full of creativity.

It seems that, at present, the researches on creative life experience are not enough and systematic. There is more theoretical research than empirical research, and mainly of them are co-relational researches, such as study on the relation between family upbringing and creative life experience; between teacher’s teaching innovation behavior and creative life experience; between social support and creative life experience; between gender, age, achievement motivation and goal orientation and creative life experience, etc.

The construct course models of creative life experience also have been built based on social cognitive theory construction. For example, Hong Su-ping (2010) thinks that the course of the generation of creative life experience contains five variables: 1) important others feedback; 2) individual internal psychological course, including creative internal motivation, creative external motivation and creative self-efficacy; 3) creative life experience. The results showed that: (1) Among the comparison of the patterns, the results showed that it runs better that creative self-efficacy before motivational variables; (2) It has positive effect on creative self-efficacy and creative extrinsic motivation that the positive feedback of important others, while not influential on creative intrinsic motivation; and (3) The individual perception of positive feedback of important others has a positive influence on creative life experience through creative self-efficacy, internal and external motivation such as creative intermediary variable, in which the individual creative self-efficacy strong predictive power of creative life experience.

**Theoretical Basis and Development of Creativity Psychology in China**

Creativity psychology is a young discipline, but its theoretical basis has a long history. Recently, it becomes a promising research area. British psychologist Galton, published *Genetic and Genius* in 1869, which is the first scientific literature of creativity psychology. In the following one hundred years, unremitting explorations have carried on about the creative question, and remarkable achievement has obtained.

In the 1940s, the creativity psychology was once recognized as personality psychology research scope, but the studies shown that creative behaviors are interacted with wisdom, motivation, personality, and influencing factors from family, school and social environments, etc. Its extension is far beyond the research scope of personality psychology, so it is recognized as an independent discipline.

Since the 1980s, a group of creativity psychology monographs have been translated and introduced into China. These work include: *An Introduction to Creativity Psychology* (Luke, 1985); *Creative Whack Pack: Success Edition, a Whack on the Side of the Head: How You can be More Creative, and creative whack pack* (Oech, 1988); *On Creativity and the Unconscious: Papers on the Psychology of Art, Literature, Love, Religion* (Freud, 1958); *How to Conduct Creative Thinking* (Hiroshi, 1987), and so on.

**The Research Focus of Creativity Psychology**

The main task of creativity psychology is to reveal the psychological process of creating activities to inspire creative potential, and provides the basis to cultivate creative talents. The main research contents are: the process of creating psychological and type; creative personality, creative intelligence, interest,
attitude, character and temperament); the influencing factors of creative play; digging and training methods of children’s creativity.

The research subjects of creativity psychology are generally creative activities, especially in scientific and psychological activity. It was based on the psychology, synthesized anthropology, sociology, pedagogy and physiology to create a behavior science research. Its research scope including various factors that impact creativity, such as measurement of creativity, studies on creative process and the method of creation, etc.

The Related Theories of Creativity

After the word “creativity” put forward by Guildford’s speech in 1950, scholars started to study creativity and made a various annotations of the word “creativity”. At present, the generally accepted definition of creativity is “a kind of ability that creating suitable, valuable and original products” (Sternberg & O’Hara, 1999, p. 251-272). There are many theories of creativity.

Amabile (1987) put forward three dimension of creativity that means creativity can be developed through interactions between 1) field skills, 2) creative skills, and 3) motivation.

Kris’s (1952) primary processing theory of thinking, from the angle of psychoanalysis, thinks that there are two main ingredients of creative thinking: primary processing, and secondary processing. Csikszentmihalyi (2001), from the angle of biological evolution and cultural evolution, put forward a system model of creativity. He thought that creativity is similar to the process leading to genetic change of biological evolution. Wallas (1926) put forward the creative process stage theory, which believes that the process of creative product production needs to experience four stages: preparation, brewing, clear, validation. Amabile (1987) proposed the “five phases of creativity development”, which argues that the generation of creative products can go through five stages roughly: questions, preparation, production, validation and results. Sternberg (1985), through clustering analysis, explored people’s creative implicit theory and found that the explanation of people on creativity contains a mixture of cognitive components and personality components, such as to find the connections between the concept of similarity and dissimilarity, to swift awareness, within aesthetic taste, within a clear motive, daring to question the social norms, etc.

The Development of Creativity Life Experience in China

Besides focusing on the creativity of special talents, psychologists should also noticed that how the normal person to show his or her unique creativity. The personal life experience also became the study subjects, and the personal creative life experience can be learned from the behaviors in people’s lives and activities.

The Research on Creative Life Experience of Chinese People

In a study on creative life experiences of students in primary and middle schools in Taiwan, Chen (2015) found that those acquire more social support may show more creative life experience; and those get more family and friends support may show higher language creativity.
Li’s (2015) study found that, the girls are more good at “using the new knowledge for perfection”, “innovation for the performing arts and life”, “visual design”, and “open mind”, etc. than boys; and in terms of “computer programming”, the boys are better than girls.

In a study carried out with senior students in a elementary school, Zhang (2015) found that “unique and interesting family style”, “actively urge of achievement” and “encourage for independent responsible” are related to the high level of creative life experience or development of creative life experience.

In a study of Taiwan students from elementary school sixth grade to college, Liu (2015) found there is a trend that students’ creative life experience generally increases along with the growth of age; and the girl’s creative life experiences are more than boys in aspects of “innovation for the performing arts and life”, “visual design” and “open mind”, while boys’ experiences are better than girls in “scientific innovation and problem solving”.

By the use of the psychological assessment tools, Luo (2010) evaluated the creativity of the 831 graduate students in mainland, and compared with the 703 in Taiwan. It is discussed in her study why mainland graduate students are not confident in the aspect of innovation behavior, and mainland girls show no advantage in the creative life experience.

Yu (2008) used the Creative Attitude Scale and Create Atmosphere Scale and carried out a preliminary investigation about the civil servants’ creativity. The results show that they have high level of creative attitude and innovation behaviors, but their creative life experience and create atmosphere are on the low level; the factors such as gender, age, knowledge have an extent affect on their creativity; and there is a significant positive correlation between create atmosphere and creative experience of life.

Methods of Developing Students’ Creativity

It seems that some suggestions may be referenced on cultivating students’ creativity: to strengthen the student’s problem consciousness, to cultivate and train students’ creative thinking; to stimulate students’ creative motivation, especially intrinsic motivation, to promote the development of creativity, to shape students’ creative personality, and to strengthen the internal force for the creativity development.

It is not difficult to get inspiration from Sternberg’s theory of creativity (Sternberg, & Elena, 1995, p. 201-219) that if we want to cultivate college students’ creativity ability, something should be done as the follows: firstly, to develop intelligence and cultivate keen innovation consciousness; secondly, to strengthen learning and cultivate the perfect knowledge structure; thirdly, to respect students and cultivate the independent thinking styles; fourthly, to teach students in accordance of their aptitude and develop their good personality; finally, to shape the creative learning environment and develop the creative campus culture.

MAIN FOCUS OF THE CHAPTER

Purpose of the Research

The purposes of this research are 1) theoretically to discuss the method and theory on enhancing creativity and then to find out the key points and putting forward appropriate intervention for college students to improve their innovative ability, and then 2) under the guidance of creativity psychology theory, tried
to put forward appropriate psychological intervention for medical students, in order to improve medical students’ exploration spirit and innovative ability.

**Significance of the Research**

On one hand, one of the world education development trends of the 21st century is the personalized education. The changes of the education modes happened that has been from homogeneous education mode (industrial economic era) to student-centered mode (knowledge economic era). According to the aptitude of the students, to cultivate creativity is the core goal in the student-centered mode.

On the other hand, the talent of new era should have the good quality that advancing with the times, thus the creative quality such as the image thinking, divergent thinking and intuition thinking are necessary. And the developing of students’ creativity and flexible quality are also needed, in order to improve their competition consciousness and innovation ability, and their ability to withstand setbacks, etc.

**The Empirical Work**

**The Survey among Medical Students**

A questionnaire survey was carried out with 97 students in clinical study in December 2014, in China Medical University. The survey aimed to explore whether the strategies is effective for improving the medical students’ creativity. The focuses of survey included: (1) the students’ demographic characteristics, including the gender, source, whether one-child or not, whether class leader or not; (2) the factors related to creative life experience levels of medical students, including problem solving, using the new knowledge, artistic innovation, visual design, life style, open mind, surprise, the new using of old bottles, and program design; (3) Factors influencing the creative ideas of medical students, including the concept of negative attitude, attention to new ideas, and team creativity; and (4) the creative behavior of medical students.

**An Overall View of the Survey**

According to the status quo of this intervention study, combining with the China medical university class setting, this research selected 97 grade students as the participates in this investigation, and the convenience sampling method was taken to divide into experimental group and control group. One “97 grade seven-year English class” and one “97 grade seven-year Japanese class” are selected as experimental group, and three “97 grade seven-year English classes” are selected as the control group. Creativity psychology intervention was put forward for the experimental group, while the control group with no interferes. At the same time, four “five-year classes” are selected, compared with the three “seven-year classes” of the control group, to investigating the overall status of China medical university students’ creative life experience.

This study issued 310 questionnaires, and 292 taken back. Eliminate the invalid 9 questionnaires, and 283 effective questionnaires were remained, namely the questionnaire recovery rate is 94.2%, and the effective rate was 97%. Among the 283 investigate effective subjects, there are 94 boys, accounting for 33.2% of all respondents; and there are 149 girls, accounting for 66.8% of all respondents. The sex ratio is 0.63, which in accordance with the distribution characteristics of university students.
There are 190 students from one-child family, accounting for 67.2% of all respondents; and there are 93 from non-one child families, accounting for 32.8% of all respondents. This reflected that the medical university students are mainly from one-child family. There are 88 class cadres, accounting for 31.1% of all respondents; and there are 195 non-class cadres, accounting for 68.9% of all respondents. There are 99 respondents from large and medium-sized cities, accounting for 35% of all respondents; there are 85 from countryside, accounting for 30% of all respondents; and there are 99 from little city, accounting for 35% of all respondents. This shown that the students of China medical university are distributed uniformly.

The Tools of the Research

There are a lot of creativity measurement methods, and the focus of this study is the creativity in everyday life of the students, so the following three questionnaires are chosen.

The Creative Life Experience Scale

The Creative Life Experience Scale of this study is compiled by Chen et al (2015), including 49 items that can be divided into nine factors: “scientific innovation problem solving”, “using the new knowledge for perfection”, “artistic innovation”, “visual design”, “life style”, “open mind”, “surprise”, “the new using of old bottles”, and “program design”. Checked by Chen et al (2015), the Cronbach alpha coefficient of the total scale is 0.95, and the Cronbach alpha coefficient of the factors are among 0.55 ~ 0.86, means that there is a high degree of internal consistency of the questionnaire. Ceng (2010) also researched the scale, and the test shown that the reliability Cronbach alpha coefficient of the factors are among 0.79 ~ 0.86. The scale is designed according to the four levels of semantic differences that “had done”, “rarely do”, “sometimes”, and “often do”, and assignment 1, 2, 3, 4 respectively.

The Creative Attitude Scale

The Creative Attitude Scale of this study is complied by Wu Jing etc., that modified from Basadur and Hauorf’s Producing Attitude Scale, with a total of 17 items, including three factors that “the negative attitude to creativity”, “pay attention to new ideas” and “team creativity”. Su (1988), through the empirical study, proved that the Cronbach alpha reliability of the scale is acceptable, also did he found that take “Creative Behavior Scale” and “Creative Life Experience Scale” as criterion, shown that the scale has good validity. The scale is designed according to the four levels of semantic differences that “strongly disagree”, “disagree”, “agree” and “strongly agree”, and assignment 1, 2, 3, 4 respectively.

The Creative Behavior Scale

The Creative Behavior Scale of this study is complied by Wu et al (1988) that modified from Scott’s Innovative behaviors Scale, with a total of seven items. Checked by Chen et al (2015), the Cronbach alpha coefficient of this scale is among 0.67 ~ 0.84. The scale is designed according to the four levels of semantic differences that “very inconformity”, “inconformity”, “conform”, “very conform”, and assignment 1, 2, 3, 4 respectively.
Creative Life Experience among Students in Medical Education

The Methods of the Research

Literature Review Method

The researchers collect related literatures on creativity psychology applications and creative life experiences. Through studying and sorting the relevant literature, carding original theory point of view, and regrouping the original documents, so as to find out the new link of them, and to provide the theoretical basis for the description of the form of creative medical students’ performance.

Participation Method

The researchers go deep into the research subject of the life background, to participate in the process of the research subject of daily social life. Based on the equality between teachers and students on the relationship, the students are proposed in daily life and provided learning guidance and personalized spiritual support.

Since the establishment of experimental class, the author actively joined the QQ online chat group of these classes, in order to know the daily activities and personality of the students, and actively participates in class learning communication, class meetings and extracurricular activities. For example, share learning experience; benign group competition; improve the class cohesion and creativity; organize creative activities out of class. And after these activities, the students are asked to write down their progress in order to receive themselves better.

Intervention Method

In order to enhance the innovation ability of the students, this study carried out with intervention activities and take creativity psychology as guidance, such as individual exchanges and collective lectures. In the two months experiment, each student weekly shared two everyday life creativities, the students were also required to contact and use the creative experience of life, such as transform old or new technology products, mainly from the three books in Table 1.

The students are also asked to share an article or a video on the development or improvement of creativity weekly, let the students not only understand everyday some creative products, more can realize the importance of creativity in learning and the development of people life so as to not only know some normal creative products of daily life, but also learn more about the importance of creativity in the human development, learning and everyday living. The content is list in Table 2:

After every activity, the students are asked to hand in their study notes, which can be the feeling after applied to real life, can be the field of knowledge what they want to be taught in next activity, and can be some advices. So, the researcher can grasp the scope and the reflection of the intervention.

Questionnaire Method

The creativity of students was measured by the scales including Creative Life Experience Scale, Creative Attitude Sale and Creative Behavior Scale. The Creative Life Experience Scale contains 49 questions, which can be divided into three subscales and nine factors; The Creative Concept Scale contains 22 items, three factors; The Creative Behavior Scale contains 7 items, one factor. The survey includes basic demography characteristics of China Medical University medical students, such as gender, source,
Table 1. The experimental group to share information

<table>
<thead>
<tr>
<th>Book</th>
<th>Content</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plastic bottles of DIY</td>
<td>Many introduced small items that made by plastic bottles, such as brush pot, flowerpot, cups, piggy bank, etc.</td>
</tr>
<tr>
<td>Daily rhapsody</td>
<td>Assembled the author’s all sorts of strange ideas, among them there are some practical ideas.</td>
</tr>
<tr>
<td>Creativity DIY</td>
<td>To utilize the creative solution to the problems in daily life.</td>
</tr>
</tbody>
</table>

Table 2. Articles about cultivating creativity

<table>
<thead>
<tr>
<th>Article</th>
<th>Author</th>
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</thead>
<tbody>
<tr>
<td>Cultivating the Collective Creativity</td>
<td>Guo Wei-wen</td>
</tr>
<tr>
<td>“The creativity force lecture” on how to improve the creativity</td>
<td>Wang Qing-ping</td>
</tr>
<tr>
<td>Educational Research of Creativity</td>
<td>Liu Guan-Hua</td>
</tr>
<tr>
<td>Analyzing the Ways to Cultivate College Students’ Creativity</td>
<td>Liu Xiao-li</td>
</tr>
<tr>
<td>The Current Situation of Higher Vocational Students’ Creativity</td>
<td>Xu Jiu-chun</td>
</tr>
<tr>
<td>Creativity Promotion Strategy of College Scientific Research Team</td>
<td>Zhang Qiong-ju</td>
</tr>
<tr>
<td>Stimulating Students’ Imagination</td>
<td>Cai Shao-yan</td>
</tr>
<tr>
<td>How to Improve Creativity</td>
<td>Ma Yu-Tao</td>
</tr>
</tbody>
</table>

whether one-child or not, whether class leader or not. And the level of creative life experience, creative attitude and creative behavior were also surveyed.

Data Collection and Analysis Method

Data Collection

The questionnaires are, taking the psychology graduate student as the main test, with unified instructions, in the class collective measured. Respondents complete questionnaires independently, and the subjects are required to choose according to their own actual situation.

Data Analysis

The original data are encoded and established into database of SPSS, all input computer. The entry logic analysis is carried out after completion, with abnormal value and missing records to replace or delete, finally using SPSS17.0 software for statistical analysis of data.

THE RESULT OF THE EMPIRICAL WORK

The author gives a statistical analysis of data by comparing of the differences that in gender, in region, in whether one-child, and in whether class cadre. And in addition, the author compared the data of the experimental group with that of the control group. The analysis under particular conditions is also taken to explore the origin of the differences.
Creative Life Experience among Students in Medical Education

The Overall Status of the Medical Students

In order to analyze the student’s creative life experience level, and the difference in gender, region, whether one-child, and whether class cadre, this research select a total of 211 students, that the students of the three seven-year control group classes and the four five-year classes, as the subject, carried on the questionnaire survey analysis.

The Demographic Characteristic

The research emphasis of China medical university 97 grade medical students’ gender, program, region, whether one-child, whether class cadres, etc., mainly for the students' demographic characteristics analysis of the statistical description of the distribution (Table 3).

Statistical Analysis

According to the classical measurement theory of psychology, when the test sample size is big enough, the subjects of the overall quality level as a continuum, and the characteristic curve is the normal distribution curve. On this basis, we believe that the medical students’ creative life experience level obeys the normal distribution curve. The following analysis is all under this premise.

Medical Students’ Overall Level of Creativity

Medical Students’ Creative Levels and Overall Life Experience

By the data in the Table 4, it can be seen that the mean score of medical students of each factor in creative living is different, the “visual design” factor get the highest score, followed by “art innovation”, “scientific innovation problem solving”, etc., and the “program design” get the lowest score. This sug-

Table 3. The demographic characteristics of medical students’ overall level

<table>
<thead>
<tr>
<th>Demographic Variables</th>
<th>Category</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td>• Boy</td>
<td>69</td>
</tr>
<tr>
<td></td>
<td>• Girl</td>
<td>142</td>
</tr>
<tr>
<td>Program</td>
<td>• Five-year</td>
<td>110</td>
</tr>
<tr>
<td></td>
<td>• Seven-year</td>
<td>101</td>
</tr>
<tr>
<td>One-child</td>
<td>• Yes</td>
<td>137</td>
</tr>
<tr>
<td></td>
<td>• No</td>
<td>74</td>
</tr>
<tr>
<td>Class cadre</td>
<td>• Yes</td>
<td>70</td>
</tr>
<tr>
<td></td>
<td>• No</td>
<td>141</td>
</tr>
<tr>
<td>Region</td>
<td>• Countryside</td>
<td>67</td>
</tr>
<tr>
<td></td>
<td>• Small city</td>
<td>67</td>
</tr>
<tr>
<td></td>
<td>• Large and medium cities</td>
<td>77</td>
</tr>
</tbody>
</table>
Creative Life Experience among Students in Medical Education

Table 4. The factor score distribution of medical students’ creative life experience

<table>
<thead>
<tr>
<th>Factors</th>
<th>Mean</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scientific innovation problem solving</td>
<td>16.08</td>
<td>3.81</td>
</tr>
<tr>
<td>Using the new knowledge for perfection</td>
<td>12.82</td>
<td>2.92</td>
</tr>
<tr>
<td>Artistic innovation</td>
<td>16.18</td>
<td>4.64</td>
</tr>
<tr>
<td>Visual design</td>
<td>17.37</td>
<td>3.96</td>
</tr>
<tr>
<td>Life style</td>
<td>11.27</td>
<td>3.01</td>
</tr>
<tr>
<td>Open mind</td>
<td>7.73</td>
<td>2.17</td>
</tr>
<tr>
<td>Surprise</td>
<td>11.09</td>
<td>2.39</td>
</tr>
<tr>
<td>The new using of old bottles</td>
<td>12.04</td>
<td>2.85</td>
</tr>
<tr>
<td>Program design</td>
<td>2.85</td>
<td>1.54</td>
</tr>
</tbody>
</table>
| Total                          | 113.44 | 21.78              

Table 5. The factor score distribution of medical students’ creative attitude scale

<table>
<thead>
<tr>
<th>Factors</th>
<th>Mean</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>The negative attitude to creativity</td>
<td>10.74</td>
<td>2.22</td>
</tr>
<tr>
<td>Pay attention to new ideas</td>
<td>11.14</td>
<td>1.78</td>
</tr>
<tr>
<td>Team creativity</td>
<td>11.17</td>
<td>1.86</td>
</tr>
</tbody>
</table>
| Total                            | 64.23  | 7.06               

gests that the factor more closely related with the daily life, the higher attention medical students may pay on, and the easier to stimulate creativity.

Medical Students’ Overall Creative Attitude

As is shown in Table 5, among the factors of students’ creative attitude, “team creativity” gets the highest score; the second is “pay attention to new ideas”; and the negative attitude to creativity is the lowest. But, there is little difference among the three factors’ score. This suggests that the medical students are holding a relatively positive attitude to generate new ideas.

Medical Students’ Overall Creative Behavior

There is only one factor of creative behavior scale, the overall mean score of medical students’ creative behavior is 30.76 and the standard deviation is 7.95.

The Difference of Medical Students’ Creativity under Particular Demographic Characteristics

The Difference of Medical Students’ Creativity between Genders

By the data in the Table 6, it can be seen that the scores of boys are slightly higher than the girls in the three scales that creative life experience scale, creative attitude scale and creative behavior scale, but
Creative Life Experience among Students in Medical Education

Table 6. The results of gender influencing on medical students’ creativity

<table>
<thead>
<tr>
<th>Scales</th>
<th>Mean</th>
<th>t</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Boy</td>
<td>Girl</td>
<td></td>
</tr>
<tr>
<td>Creative Life Experience</td>
<td>114.33</td>
<td>113.00</td>
<td>0.46</td>
</tr>
<tr>
<td>Creative Attitude Scale</td>
<td>64.52</td>
<td>64.09</td>
<td>0.42</td>
</tr>
<tr>
<td>Creative Behavior Scale</td>
<td>31.03</td>
<td>30.63</td>
<td>0.20</td>
</tr>
</tbody>
</table>

the difference is not significant (as is shown in Table 6, the test result of the three scales, p>0.05). This shows that medical students’ creative life experience, creative attitude and creative behavior level does not differ by gender.

The Differences of Medical Students’ Creativity on Whether One-Child

From the data in the Table 7, it can be seen that the scores of one-child students are slightly higher than the non-one child in the three scales that creative life experience scale, creative attitude scale and creative behavior scale, but the difference is not significant (as is shown in Table 7, the test result of the three scales, p>0.05). This shows that there is little influence of whether one-child or not on the level of their creativity.

The Difference of Medical Students’ Creativity on Whether Class Cadre

From the data in the Table 8, it can be seen that the scores of class cadre students are slightly higher than those not class cadre students in the three scales that creative life experience scale, creative attitude scale and creative behavior scale, but only the creative life experience scale score has significant difference between class cadre students and not class cadre students (as is shown in Table 8, p≤0.05).

Table 7. The results of whether one-child influencing on medical students’ creativity

<table>
<thead>
<tr>
<th>Scales</th>
<th>Mean</th>
<th>t</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>One-Child</td>
<td>Non-One Child</td>
<td></td>
</tr>
<tr>
<td>Creative Life Experience</td>
<td>114.38</td>
<td>111.69</td>
<td>0.86</td>
</tr>
<tr>
<td>Creative Attitude Scale</td>
<td>64.55</td>
<td>63.64</td>
<td>0.9</td>
</tr>
<tr>
<td>Creative Behavior Scale</td>
<td>31.31</td>
<td>29.76</td>
<td>1.35</td>
</tr>
</tbody>
</table>

Table 8. The results of whether class cadre influencing on medical students’ creativity.

<table>
<thead>
<tr>
<th>Scales</th>
<th>Mean</th>
<th>t</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Class Cadre</td>
<td>Not Class Cadre</td>
<td></td>
</tr>
<tr>
<td>Creative Life Experience</td>
<td>118.34</td>
<td>111.00</td>
<td>2.23</td>
</tr>
<tr>
<td>Creative Attitude Scale</td>
<td>64.09</td>
<td>63.30</td>
<td>-0.21</td>
</tr>
<tr>
<td>Creative Behavior Scale</td>
<td>31.10</td>
<td>30.06</td>
<td>0.43</td>
</tr>
</tbody>
</table>
This illustrated that the class cadre medical students’ creative life experience level is significantly higher than the not class cadre students, and this may be associated with the responsibilities of the class cadre. After all, the class cadre students often organize class activities and solve problems in class. Further study of the statistical analysis has been taken on the various factors of creative life experience scale, and the results are shown in the Table 9.

By the data in the Table 9, it can be seen that the class cadre students’ score are slightly higher than the not class cadre students’ in all the factors of the creative life experience scale. However, there is only significant difference of scores in the two factors that “artistic innovation” and “program design” between those class cadre students and not class cadre students (as is shown in Table 9, p≤0.05), and the difference of the other factors’ scores are not significant.

The Difference of Medical Students’ Creativity among Regions

By the data in the Table 10, it can be seen that there are significant differences among the medical students’ regions in all the three scales’ scores that the creative life experience scale, the creative attitude scale and the creative behavior scale. And the after comparison has shown that the scores of those form countryside students are significantly lower than those of large and medium-sized cities in all the three scales that the creative life experience scale, the creative attitude scale and the creative behavior scale. However, the score difference is not significant between those students from large and medium cities and those students from small towns.

This illustrated that the superior living environment, to some extent, has the benefit to cultivate the students’ creativity. Further study has been taken on the various factors of creative life experience scale, and the results are shown in the Table 11.

By the data in the Table 11, it can be seen that there are significant differences of students from different regions in the four factors that “scientific innovation problem solving”, “artistic innovation”, “visual design” and “life style”. And the superiority of the students from cities to those from countryside is just embodied in the four aspects.

<table>
<thead>
<tr>
<th>Factors</th>
<th>Mean</th>
<th>t</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Class Cadre</td>
<td>Not Cadre</td>
<td></td>
</tr>
<tr>
<td>Scientific innovation problem solving</td>
<td>16.64</td>
<td>15.79</td>
<td>1.53</td>
</tr>
<tr>
<td>Using the new knowledge for perfection</td>
<td>12.94</td>
<td>12.75</td>
<td>0.45</td>
</tr>
<tr>
<td>Artistic innovation</td>
<td>17.24</td>
<td>15.65</td>
<td>2.38</td>
</tr>
<tr>
<td>Visual design</td>
<td>17.93</td>
<td>17.1</td>
<td>1.44</td>
</tr>
<tr>
<td>Life style</td>
<td>11.81</td>
<td>11.00</td>
<td>1.86</td>
</tr>
<tr>
<td>Open mind</td>
<td>8.09</td>
<td>7.56</td>
<td>1.66</td>
</tr>
<tr>
<td>Surprise</td>
<td>11.16</td>
<td>11.06</td>
<td>0.28</td>
</tr>
<tr>
<td>The new using of old bottles</td>
<td>12.56</td>
<td>11.78</td>
<td>1.88</td>
</tr>
<tr>
<td>Program design</td>
<td>4.19</td>
<td>3.75</td>
<td>1.94</td>
</tr>
</tbody>
</table>
Creative Life Experience among Students in Medical Education

Table 10. The results of region influencing on medical students’ creativity

<table>
<thead>
<tr>
<th>Scales</th>
<th>Mean square</th>
<th>F</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Inter-Group</td>
<td>Intra-Group</td>
<td></td>
</tr>
<tr>
<td>Creative Life Experience Scale</td>
<td>2977.39</td>
<td>450.19</td>
<td>6.61</td>
</tr>
<tr>
<td>Creative Attitude Scale</td>
<td>283.18</td>
<td>47.54</td>
<td>5.96</td>
</tr>
<tr>
<td>Creative Behavior Scale</td>
<td>628.97</td>
<td>57.76</td>
<td>10.89</td>
</tr>
</tbody>
</table>

Table 11. The factor scores of creative life experience scale on regions

<table>
<thead>
<tr>
<th>Factors</th>
<th>Mean square</th>
<th>F</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Inter-Group</td>
<td>Intra-Group</td>
<td></td>
</tr>
<tr>
<td>Scientific innovation problem solving</td>
<td>64.99</td>
<td>14.03</td>
<td>4.63</td>
</tr>
<tr>
<td>Using the new knowledge for perfection</td>
<td>9.18</td>
<td>8.12</td>
<td>0.08</td>
</tr>
<tr>
<td>Artistic innovation</td>
<td>269.46</td>
<td>19.19</td>
<td>14.04</td>
</tr>
<tr>
<td>Visual design</td>
<td>59.19</td>
<td>15.29</td>
<td>3.87</td>
</tr>
<tr>
<td>Life style</td>
<td>62.28</td>
<td>8.52</td>
<td>7.31</td>
</tr>
<tr>
<td>Open mind</td>
<td>10.66</td>
<td>4.64</td>
<td>2.29</td>
</tr>
<tr>
<td>Surprise</td>
<td>10.45</td>
<td>5.67</td>
<td>1.85</td>
</tr>
<tr>
<td>The new using of old bottles</td>
<td>9.18</td>
<td>8.12</td>
<td>1.13</td>
</tr>
<tr>
<td>Program design</td>
<td>0.39</td>
<td>2.39</td>
<td>0.17</td>
</tr>
</tbody>
</table>

The Difference of Medical Students’ Creativity on Different Program

By the data in the Table 12, it can be seen that the scores of five-year program students are higher than that of seven-year program students in all the three scales that the creative life experience scale, the creative attitude scale and the creative behavior scale. Especially in the creative attitude scale and creative behavior scale, there are significant differences between different programs. Further study has been taken on the various factors of creative attitude scale, and the results are shown in the Table 13.

By the data in the Table 13, it can be seen that in “the negative attitude to creativity” factor, the seven-year program students’ scores are higher than that of the five-year program students, and there is a significant difference between the different programs. But in the other two factors that “pay attention to new ideas” and “team creativity”, the seven-year program students’ scores are lower than that of the five-year students, and there is a significant difference between the different programs.

The factor “the negative attitude to creativity” is a inverse scored factor, namely that the higher score the subject get, the more negative his/her attitude is to creativity. So, compared with seven-year program students, the five-year students take a more positive attitude and pay more attention to new ideas, and have stronger team creativity.
Table 12. The results of program influencing on medical students’ creativity

<table>
<thead>
<tr>
<th>Scales</th>
<th>Mean</th>
<th>t</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Seven-Year</td>
<td>Five-Year</td>
<td></td>
</tr>
<tr>
<td>Creative Life Experience Scale</td>
<td>112.93</td>
<td>113.99</td>
<td>-0.35</td>
</tr>
<tr>
<td>Creative Attitude Scale</td>
<td>61.56</td>
<td>66.68</td>
<td>-5.64</td>
</tr>
<tr>
<td>Creative Behavior Scale</td>
<td>26.73</td>
<td>34.47</td>
<td>-8.06</td>
</tr>
</tbody>
</table>

Table 13. The factor scores of creative attitude scale on different programs

<table>
<thead>
<tr>
<th>Factors</th>
<th>Mean</th>
<th>t</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Seven-Year</td>
<td>Five-Year</td>
<td></td>
</tr>
<tr>
<td>The negative attitude to creativity</td>
<td>11.5</td>
<td>9.92</td>
<td>5.51</td>
</tr>
<tr>
<td>Pay attention to new ideas</td>
<td>10.53</td>
<td>11.81</td>
<td>-5.60</td>
</tr>
<tr>
<td>Team creativity</td>
<td>10.66</td>
<td>11.72</td>
<td>-4.31</td>
</tr>
</tbody>
</table>

The Investigation and Analysis of Medical Students’ Creativity under Experimental Conditions

Data of Demographic Characteristics

The subjects of experimental group in this study are mainly the students of China Medical University 97 grade seven-year class. Include the Japanese class students and the English class students, with a total number of 72. The demographic characteristic of the experimental group subjects is shown in Table 14.

Table 14. The demographic characteristics of the experimental group

<table>
<thead>
<tr>
<th>Demographic Variables</th>
<th>Category</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td>Boy</td>
<td>25</td>
</tr>
<tr>
<td></td>
<td>Girl</td>
<td>47</td>
</tr>
<tr>
<td>One-child</td>
<td>Yes</td>
<td>53</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>19</td>
</tr>
<tr>
<td>Class cadre</td>
<td>Yes</td>
<td>18</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>54</td>
</tr>
<tr>
<td>Region</td>
<td>Countryside</td>
<td>18</td>
</tr>
<tr>
<td></td>
<td>Small city</td>
<td>31</td>
</tr>
<tr>
<td></td>
<td>Large and medium cities</td>
<td>23</td>
</tr>
</tbody>
</table>
**Creative Life Experience among Students in Medical Education**

**Statistical Analysis**

**The General Level of Creativity among Medical Students in Experimental Group**

**The Experimental Group Medical Students’ Creative Life Experience in Each Factor**

By the data in the Table 15, it can be seen that the experimental group students get different scores in different factors. Among the factors, the “visual design” score is the highest, followed by “artistic innovation”, “scientific innovation problem solving”, etc., and the “program design” score is the lowest. This shows that the creative life experience level of the experimental group medical students conforms to the overall level of the medical students.

**The Experimental Group Medical Students’ Creative Attitude in Each Factor**

By the data in the Table 16, it can be seen that among the medical students’ creative attitude factor, the “pay attention to new ideas” score is highest, the second is “team creativity”, and the lowest is “the negative attitude to creativity”. This conforms to the overall level of the medical students, and the experimental groups hold the same positive attitude to the new ideas with the other students.

*Table 15. The descriptive statistics of the experimental group medical students’ scores in each factor of the creative life experience scale*

<table>
<thead>
<tr>
<th>Factors</th>
<th>Mean</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scientific innovation problem solving</td>
<td>15.79</td>
<td>4.22</td>
</tr>
<tr>
<td>Using the new knowledge for perfection</td>
<td>14.51</td>
<td>2.69</td>
</tr>
<tr>
<td>Artistic innovation</td>
<td>16.93</td>
<td>5.48</td>
</tr>
<tr>
<td>Visual design</td>
<td>19.74</td>
<td>4.36</td>
</tr>
<tr>
<td>Life style</td>
<td>11.21</td>
<td>3.54</td>
</tr>
<tr>
<td>Open mind</td>
<td>9.42</td>
<td>1.87</td>
</tr>
<tr>
<td>Surprise</td>
<td>12.79</td>
<td>2.82</td>
</tr>
<tr>
<td>The new using of old bottles</td>
<td>13.25</td>
<td>2.84</td>
</tr>
<tr>
<td>Program design</td>
<td>4.67</td>
<td>1.56</td>
</tr>
<tr>
<td>Total</td>
<td>120.97</td>
<td>23.45</td>
</tr>
</tbody>
</table>

*Table 16. The descriptive statistics of the experimental group medical students’ scores in each factor of the creative attitude scale*

<table>
<thead>
<tr>
<th>Factors</th>
<th>Mean</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>The negative attitude to creativity</td>
<td>10.47</td>
<td>3.01</td>
</tr>
<tr>
<td>Pay attention to new ideas</td>
<td>12.54</td>
<td>1.70</td>
</tr>
<tr>
<td>Team creativity</td>
<td>12.19</td>
<td>1.73</td>
</tr>
<tr>
<td>Total</td>
<td>59.22</td>
<td>5.57</td>
</tr>
</tbody>
</table>
The Experimental Group Medical Students’ Creative Behavior

The creative behavior scale has only one factor; the average was 19.02, lower than the medical students’ overall level of creative behavior (the mean of the total is 30.76 and the standard deviation is 7.95).

The Experimental Group Medical Students’ Creativity under Particular Demographic Factors Difference

The Difference of Experimental Group Subjects’ Creativity between Gender

By the data in the Table 17, it can be seen that, in the experimental group, the boys get higher scores than the girls in all the three scales that “creative life experience scale”, “creative attitude scale” and “creative behavior scale”. However, the difference is not significant (as is shown in Table 17, the test result of the three scales, p>0.05), and this conforms to the overall gender differences of the total medical students.

The Difference of Experimental Group Subjects’ Creativity on Whether One-Child

By the data in the Table 18, it can be seen that, in the experimental group, the one-child students get higher score than those none-one child students in the two scales that “creative life experience scale” and “creative behavior scale”. However, in the “creative attitude scale”, the one-child students get lower score than those none-one child students. The differences are not significant in all the three scales. The results of “creative life experience scale” and “creative behavior scale” conform to the medical students’ overall creativity level, and there is little difference whether one-child or not on medical students’ creativity.

The Difference of Experimental Group Subjects’ Creativity on Whether Class Cadre

By the data in the Table 19, it can be seen that in the experimental group, the class cadre students get higher score than those not class cadre students in the two scales that “creative life experience scale” and “creative behavior scale”. However, in the “creative attitude scale”, the class cadre students get lower score than those not class cadre students. The differences are not significant in all the three scales. The results of “creative life experience scale” and “creative behavior scale” conform to the medical students’ overall creativity level, and there is little difference whether class cadre or not on medical students’ creativity.

The Difference of Experimental Group Subjects’ Creativity among Regions

By the data in the Table 20, it can be seen that there is no significant difference among students of different regions in the scores of all the three scales that “creative life experience scale”, “creative attitude scale” and “creative behavior scale”.

Table 17. The results of gender influencing on experimental group subjects’ creativity

<table>
<thead>
<tr>
<th>Scales</th>
<th>Mean</th>
<th>t</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Boy</td>
<td>Girl</td>
<td></td>
</tr>
<tr>
<td>Creative Life Experience</td>
<td>124.36</td>
<td>119.17</td>
<td>0.81</td>
</tr>
<tr>
<td>Creative Attitude Scale</td>
<td>59.44</td>
<td>59.11</td>
<td>0.24</td>
</tr>
<tr>
<td>Creative Behavior Scale</td>
<td>19.80</td>
<td>18.62</td>
<td>1.22</td>
</tr>
</tbody>
</table>
Table 18. The results of whether one-child influencing on experimental group subjects’ creativity

<table>
<thead>
<tr>
<th>Scales</th>
<th>Mean</th>
<th>t</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>One-Child</td>
<td>Non-One Child</td>
<td></td>
</tr>
<tr>
<td>Creative Life Experience Scale</td>
<td>120.62</td>
<td>121.95</td>
<td>-0.21</td>
</tr>
<tr>
<td>Creative Attitude Scale</td>
<td>59.53</td>
<td>58.59</td>
<td>0.29</td>
</tr>
<tr>
<td>Creative Behavior Scale</td>
<td>19.00</td>
<td>19.11</td>
<td>-0.11</td>
</tr>
</tbody>
</table>

Table 19. The results of whether class cadre influencing on experimental group subjects’ creativity

<table>
<thead>
<tr>
<th>Scales</th>
<th>Mean</th>
<th>t</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Class Cadre</td>
<td>Not Class Cadre</td>
<td></td>
</tr>
<tr>
<td>Creative Life Experience Scale</td>
<td>127.06</td>
<td>118.94</td>
<td>1.28</td>
</tr>
<tr>
<td>Creative Attitude Scale</td>
<td>58.83</td>
<td>59.35</td>
<td>-0.34</td>
</tr>
<tr>
<td>Creative Behavior Scale</td>
<td>19.89</td>
<td>18.74</td>
<td>1.21</td>
</tr>
</tbody>
</table>

Table 20. The results of region influencing on experimental group subjects’ creativity

<table>
<thead>
<tr>
<th>Scales</th>
<th>Mean square</th>
<th>F</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Inter-Group</td>
<td>Intra-Group</td>
<td></td>
</tr>
<tr>
<td>Creative Life Experience Scale</td>
<td>1538.46</td>
<td>521.12</td>
<td>2.95</td>
</tr>
<tr>
<td>Creative Attitude Scale</td>
<td>56.72</td>
<td>30.30</td>
<td>1.87</td>
</tr>
<tr>
<td>Creative Behavior Scale</td>
<td>33.27</td>
<td>11.67</td>
<td>2.85</td>
</tr>
</tbody>
</table>

This result conflicts with the overall level of medical students’ creativity. According to the overall result, regions of the medical students affect the medical students’ creativity level, however, in the experimental group, regions of the medical students do not affect the medical students’ creativity level.

The Comparison of Medical Students’ Creativity between the Experimental Group and the Control Group

Demographic Characteristics of the Experimental Group and Control Group Medical Students

As is shown in Table 21, the distribution in demographic factors of the experimental group and control group students has certain difference, but there is no significant difference. This, from a certain extent, proves that the division of the experimental group is feasible.

Levels of Creativity in Experimental Group and Control Group

By the data in the Table 22, it can be seen that in the creative life experience scale and creative attitude scale, the experimental group’ scores are higher than that of the control group, and there are significant
differences. But in the creative behavior scale, the experimental group’s score was significantly lower than the control group. This shows that after the psychological intervention, the experimental group medical students’ creative life experience and creative attitude is better than the control group, namely that certain psychological intervention can improve medical students’ creative life experiences and creative attitude level.

In order to further compare the creative life experience level of experimental group and control group, the different t tests have taken in every factor score of creative life experience scale.

Table 21. The difference between experimental group and control group in the demographic characteristics

<table>
<thead>
<tr>
<th>Demographic Variables</th>
<th>Category</th>
<th>Number</th>
<th>Experimental Group</th>
<th>Control Group</th>
<th>χ²</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td>Boy</td>
<td>25</td>
<td>69</td>
<td></td>
<td>0.10</td>
<td>0.75</td>
</tr>
<tr>
<td></td>
<td>Girl</td>
<td>47</td>
<td>142</td>
<td></td>
<td>1.83</td>
<td>0.20</td>
</tr>
<tr>
<td>One-child</td>
<td>Yes</td>
<td>53</td>
<td>137</td>
<td></td>
<td>1.67</td>
<td>0.21</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>19</td>
<td>74</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Class cadre</td>
<td>Yes</td>
<td>18</td>
<td>70</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>54</td>
<td>141</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Region</td>
<td>Countryside</td>
<td>18</td>
<td>67</td>
<td></td>
<td>3.11</td>
<td>0.07</td>
</tr>
<tr>
<td></td>
<td>Small city</td>
<td>31</td>
<td>67</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Large and medium cities</td>
<td>23</td>
<td>77</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 22. The result of medical students’ creativity difference between the experimental group and the control group

<table>
<thead>
<tr>
<th>Scales</th>
<th>Mean</th>
<th>t</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Creative Life Experience Scale</td>
<td>120.97</td>
<td>2.49</td>
<td>0.014</td>
</tr>
<tr>
<td>Creative Attitude Scale</td>
<td>64.23</td>
<td>6.13</td>
<td>0.000</td>
</tr>
<tr>
<td>Creative Behavior Scale</td>
<td>19.03</td>
<td>-17.12</td>
<td>0.000</td>
</tr>
</tbody>
</table>

By the data in the Table 23, it can be seen that the experimental group students’ score is significantly higher than those of the control group in the six factors that “using the new knowledge for perfection”, “visual design”, “open mind”, “surprise”, “the new using of old bottles” and “program design”. In the factor “artistic innovation”, the experimental group students’ scores also higher than the control group, but there is no significant difference. In the two factors that “scientific innovation problem solving” and “life style”, the experimental group students’ score are slightly lower than that of the control group, but the difference is not significant.

Compared with the control group, psychological intervention mainly influenced the experimental group medical students’ ability to apply the new knowledge for perfection, the degree of visual design and open mind, the ability to create surprise, and computer programming.
Creative Life Experience among Students in Medical Education

Table 23. The factor scores of creative life experience scale between the experimental group and the control group.

<table>
<thead>
<tr>
<th>Factors</th>
<th>Mean</th>
<th>t</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Experimental Group</td>
<td>Control Group</td>
<td></td>
</tr>
<tr>
<td>Scientific innovation problem solving</td>
<td>15.79</td>
<td>16.07</td>
<td>-0.531</td>
</tr>
<tr>
<td>Using the new knowledge for perfection</td>
<td>14.51</td>
<td>12.82</td>
<td>4.345</td>
</tr>
<tr>
<td>Artistic innovation</td>
<td>16.93</td>
<td>16.17</td>
<td>1.05</td>
</tr>
<tr>
<td>Visual design</td>
<td>19.74</td>
<td>17.37</td>
<td>4.26</td>
</tr>
<tr>
<td>Life style</td>
<td>11.21</td>
<td>11.27</td>
<td>-0.14</td>
</tr>
<tr>
<td>Open mind</td>
<td>9.42</td>
<td>7.73</td>
<td>5.88</td>
</tr>
<tr>
<td>Surprise</td>
<td>12.79</td>
<td>11.09</td>
<td>4.59</td>
</tr>
<tr>
<td>The new using of old bottles</td>
<td>13.25</td>
<td>12.04</td>
<td>3.12</td>
</tr>
<tr>
<td>Program design</td>
<td>4.67</td>
<td>3.89</td>
<td>3.65</td>
</tr>
</tbody>
</table>

In order to further compare the creative life experience level of experimental group and control group, the difference in t test has taken in every factor score of creative attitude scale.

By the data in the Table 24, it can be seen that the experimental group students’ scores are significantly higher than that of the control group in the two factors that “pay attention to new ideas” and “team creativity”. As for “the negative attitude to creativity”, the experimental group students’ scores are slightly lower than that of the control group, but there is no significant difference. The results show that the experimental group pays more attention to new ideas than the control group, hold a more positive attitude to the new ideas and stronger team creativity.

Table 24. The factor scores of creative attitude scale between the experimental group and the control group.

<table>
<thead>
<tr>
<th>Factors</th>
<th>Mean</th>
<th>t</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Experimental Group</td>
<td>Control Group</td>
<td></td>
</tr>
<tr>
<td>The negative attitude to creativity</td>
<td>10.48</td>
<td>10.74</td>
<td>-0.70</td>
</tr>
<tr>
<td>Pay attention to new ideas</td>
<td>12.54</td>
<td>11.14</td>
<td>5.82</td>
</tr>
<tr>
<td>Team creativity</td>
<td>12.20</td>
<td>11.17</td>
<td>4.11</td>
</tr>
</tbody>
</table>
DISCUSSION

The Overall Status of the Medical Students’ Creativity

The Overall Status of the Medical Students’ Creative Life Experience

Among the factors of medical students’ creative life experience, the “visual design” factor gets the highest score, followed by the “artistic innovation”, “scientific innovation problem solving”, “using the new knowledge for perfection”, “the new using of old bottles”, “life style”, “surprise”, and “open mind”, and “program design” get the lowest score. This result proved that, the design of the medical students’ visual life, performing of arts innovation and scientific innovation ability to resolve the problem are strong. The possible reason may be that medical students have more practice courses, and actively organize extracurricular activities.

The Overall Status of the Medical Students’ Creative Attitude

There is little difference in the three factors of creative attitude of medical students, the team creativity get the highest scores, followed is the attention to new ideas, the least is the negative attitude to new ideas. This suggests that the team creativity of the medical students is strong, and attention is paid to generate new ideas. The low score of the negative attitude to new ideas, namely that the subjects do not think they are negative.

Differences in the Levels of Creativity between Different Groups of Demographic Characteristics

In terms of the gender, boys’ scores were higher than girls’ in all the three questionnaires that creative life experience, creative attitude, and creative behavior, but the difference is not significant (p > 0.05). This shows that there is no significant difference of gender in the overall level of medical students’ creative life experience, namely that there are no gender differences in the overall level.

In terms of whether one-child or not, the scores of medical students that from one-child family are all slightly higher than that from non-one child family, on the three scales that creative life experience scale, creative attitude scale and creative behavior scale. But, there is no significant difference. This indicates that there is no significant difference of whether one-child or not in the overall level of medical students’ creative life experience.

In terms of whether class cadre or not, the scores of the class cadre of medical students are all higher than those not class cadre in all the three scales that creative life experience scale, creative attitude scale and creative behavior scale, especially the creative life experience scale has significant difference. And about the factors, the differences are significant in the “artistic innovation”. This may be because the class cadre at ordinary times accumulated some experience in organizing class activities, and the accumulation makes the class cadre’s creative life experience level is higher than those not class cadre.

In terms of the region of the students, the score difference of the three scales that creative life experience scale; creative attitude scale and creative behavior scale are all significant. Especially the scores of those students from countryside, that in the three scales score was significantly lower than those students’ that from large or medium-sized cities. This may be because that the city’s material level, culture science
and technology, and education teaching quality is better than that of the countryside, and the pace of life is faster than that of the countryside.

In terms of the educational program and grades, the five-year students’ scores in three scales that creative life experience scale, creative attitude scale and creative behavior scale are all higher than that of seven-year program students, especially the scores of the creative attitude scale and creative behavior scale, there are significant difference in the two scales. This may be because of seven-year program students’ academic task is heavy, and their pressure is bigger than the five-year students. So the seven-year students might be more concentrate than the five-year students at ordinary times, and the five-year students may have more time to enrich life.

The Differences of the Medical Students’ Creativity between the Experimental Group and the Control Group

The Differences of Creative Life Experience between the Experimental Group and the Control Group

The total score of the experimental group on the creative life experience scale is significantly higher than the control group. Except for the three factors that “scientific innovation problem solving”, “artistic innovation” and “life style”, the experimental group is significantly higher than the control group in the other six factors that “using the new knowledge for perfection”, “visual design”, “open mind”, “surprise”, “the new using of old bottles”, and “program design”. This proved that the creative psychological intervention is helpful to improve the level of medical students’ creative life experience, and further studies can start from the discrepant six factors.

The Differences of the Creative Attitudes between the Experimental Group and the Control Group

The total score of the experimental group on the creative attitude scale is significantly higher than the control group. Further analysis of the three creative attitude scale factor have found that the experimental group is significantly higher than the control group on the two factors that “attach great importance to the new ideas” and “team creativity”. This proved that the experimental group students pay more attention to new ideas, and their team creativity is stronger than the control group. The creative psychological intervention has a certain improvement effect for medical students’ team creativity, and makes the medical students pay more attention to new ideas.

The Differences of Creative Behavior between the Experimental Group and the Control Group

The score of the experimental group on the creative behavior scale is significantly lower than the control group. This may be because of the experimental intervention too theoretical and ignore the life practice.
CONCLUSION AND SUGGESTIONS

Overall Conclusion

Based on the measuring of the overall creativity level of the experimental group, the result showed that the experimental group of medical students’ creativity level is as same as the medical students’ overall level of creativity. The demographic variables such as gender, and one-child etc., does not affect the level of medical students’ creativity.

The differences inspection of Creative Life Experience Scale, between the experimental group and the control group, found that the total score of the experimental group on the Creative Life Experience Scale is significantly higher than the control group, especially in the six factors that “scientific innovation problem solving”, “visual design”, “open mind”, “surprise”, “the new using of old bottles”, and “program design”. Namely that compared with the control group, the psychological intervention improved the creative life experience level of the experimental group.

The differences inspection of Creative Attitude Scale, between the experimental group and the control group, found that the score of experimental group on the two factors that “pay attention to new ideas” and “team creativity” are significantly higher than the control group. Namely that the experimental intervention has a positive impact to improve the team creativity and let the students pay more attention to new ideas.

Suggestions

According to the characteristic of medical students and the current medical education system in China, there are some suggestions for the improvement of medical students’ creativity.

Cultivating Medical Students’ Innovation Sense

In the first place, through the school education and social practice, let the students know that the creation is not only society put forward to develop and solve new problems, and it is the very request that interpreted as their needs and desire to create new things; Second, encourage the practice of medical students’ participate in the transformation activities of their world outlook, such as group counseling, in order to the further development of college students’ innovation consciousness. At the same time, in reforming of the objective world, the wisdom of the medical students will increase, thus further promote their innovative consciousness.

Cultivating Students’ Interests in Discovering New Things

Take cultivating the students’ interest as the breakthrough of their creativity training, and guiding their interest to new things and new stimulus. Teachers should try to meet the psychological needs of students, arouse their enthusiasm and curiosity of creation techniques, make the student in a stimulated state, so as to maintain their interest in knowledge, always keep creative students’ interest and enthusiasm to the creation and innovation. It is proved that interest can make the students concentrate, only when they have strong interest on the thing itself, will their attention to things, thinking and research be aroused, will their creativity be stimulated.
Cultivating Students' Ability of Grasping and Using Knowledge Flexibly

The existing teaching mode must be reformed to train the innovative ability of medical students. Previous talent training mode of medical institutions is mainly “cramming” way of teaching, cannot train the medical students to be full of exploring and reforming spirit and with a strong creative ability. The main body role of students in learning should be given full play, so as to cultivate the students’ initiative, enthusiasm and independence. Fully excavate the potential of students, build the education mode to take the teacher as the leadership, take the student as the main body. At the same time of teaching medical students the basic knowledge and basic theory, it is more important is to teach them the good way of thinking. Cultivating the innovative thinking ability, and strive to cultivate creative medical talents that knowing how to learn, have good thinking, and diligent to explore.

THE LIMITATIONS OF THIS STUDY

First of all, this research hypothesis that, before the intervention, the control group and experimental group are homogeneous groups that there is no difference between the two groups. It is just on this basis, the research take the control group for reference, carried on a comparative study of the experimental group and the control group. The conclusion of this study on the experimental group and the control group, is based on the assumptions that the control group’s positive mental quality status has not any change in the process of experimental group intervention. Limited to the limitation of time, manpower and material resources, this study did not do a good control for the history and the mature factors, so there are some limitations with the experimental results infer. Secondly, the purpose of creative psychology intervention is to improve the students’ creativity and creative life experience level, but this is a long-term process. This study intervention for the duration of only two months, the time is too short to improve the level of a person’s creativity; this may led to the experimental results not ideal in some aspects. And last, this study assumes that the subjects do not have an impact on their own creative things, and the outside world without change or the changes will not affect the creative of the subjects. But in real life, the person’s creativity is influenced by many factors. Both subjective factors and objective factors are likely to affect the subjects, which may affect the experiment result.

ACKNOWLEDGMENT

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**KEY TERMS AND DEFINITIONS**

**Big Creativity:** The common sense of creativity, in this article, it especially refers to the creative performance in frontier technology development and professional field.

**Central Committee of the Communist Party of China:** The central authority of the communist party of China, elected by Chinese communist party national congress.

**Five-year Classes:** A kind of education system that requires students to complete the learning five years.

**QQ Online Chat Group:** The online chat site created by Tencent Company, China.

**Small Creativity:** The special sense of creativity, in this article, it refers to the creative performance in daily life.

**Seven-Year Classes:** A kind of education system that requires students to complete the learning seven years.

**The State Council:** The highest executive organ of China, it is the highest state administrative organ of China.
The 97 Grade Students: The norm of student’s grade distinguish in China Medical University, refers to the 97th batch of students since the university established. It should be noted that the grade of China medical university students is not necessarily completely corresponding with the year, that is to say, sometimes there is only one grade students in several years, however, there are two or more grade students in one year.
Section 3

Instruction Models
Chapter 9
International Center for Studies in Creativity: Curricular Overview and Impact of Instruction on the Creative Problem-Solving Attitudes of Graduate Students

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Buffalo State, State University of New York, USA

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Nur Cayirdag
Istanbul Sabahattin Zaim University, Turkey

ABSTRACT

This chapter provides an overview of the programs offered by the International Center for Studies in Creativity (ICSC) at Buffalo State, State University of New York, where creativity is taught and studied extensively at the graduate and undergraduate level. Following the discussion on creativity as a 21st century skill and perennial need for creativity in the workforce, programs and courses are introduced along with the historical roots and philosophy of creativity at ICSC. The Creative Problem Solving Model, which represents the core of the curriculum, is described. The chapter also presents the results of the study regarding the impact of the graduate program on the creative problem solving attitudes of the graduate students based on qualitative and quantitative data.

INTRODUCTION

Creativity has been perceived as an elusive and complex construct (Brown, 1989; Ford & Harris, 1992; Sternberg, 2006). The content we present in this chapter centers on creativity, however, it is quite tangible. We will present information about programs and curricula focused on the development of creativity and provide empirical evidence showing impact of such creativity programs. More specifically, such creativity models as Creative Problem Solving: The Thinking Skills Model is described as the theoretical underpinnings are briefly discussed.

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The International Center for Studies in Creativity (ICSC) has developed creativity courses and programs over the decades, founded on certain beliefs about creativity. We believe that:

- Creativity is a crucial life skill that helps individuals and societies survive, grow, and prosper.
- Everybody has creative potential although its expressions can vary both in degree and style.
- Creativity can be cultivated, developed, and taught.

The current chapter aims to explain and present:

- Creativity as high demand 21st century skill.
- The mission and history of the ICSC.
- Programs offered by ICSC and curricular overview.
- Results of the qualitative and quantitative data collected from graduate students.

**BACKGROUND**

**Life in the 21st Century: The Age of Innovation**

It seems every generation claims that theirs is a time of change. For example, in the mid-1970s Rollo May (1975) observed in his classic book *The Courage to Create*:

*Every profession can and does require some creative courage. In our day, technology and engineering, diplomacy, business, and certainly teaching, all of these professions and scores of others are in the midst of radical change and require courageous persons to appreciate and direct this change.* (p. 22)

While each successive generation can legitimately claim that they lived in a time of increased change, it is no stretch of the imagination to say that life in the early part of the 21st century has ushered in unprecedented levels of change. The exponential rate of change is easily seen in the time it takes humans to double the amount of available knowledge. American futurist, designer and inventor, Buckminster Fuller (1981) famously calculated that all of the information accumulated by human kind up to year one of the modern calendars had doubled in the successive 1500 years, that is by the beginning of the 1500’s. It then took a short 250 years for knowledge to double again, between 1500 and 1750. Picking up the pace, it was estimated that human knowledge then doubled in 150 years from 1750 to 1900. The amount of time it took for information to double dropped then to approximately every 25 years from the beginning to the middle of the 20th century. In a world driven by technology, the rate at which accumulated knowledge doubles is now a dizzying 11 hours (IBM, 2006).

Calculations in regard to the time it takes for knowledge to double can feel a bit abstract. Let’s look at the speed of change that may have a more direct impact on our households, that is the time it takes products we use on a daily basis to become obsolete. Evidence for the increase in the pace of change becomes readily apparent when one examines the duration of product life cycles, which is typically described as Introduction, Growth, Maturity, and, finally, Decline. In the first half of the 20th century it took more than a decade for the following well-known products to move just from Introduction to the Growth stage: dishwashers (59 years), steam irons (14 years), power lawn mowers (16 years), garbage
disposals (20 years), and automatic coffee makers (14 years). In the latter part of the same century the duration from the point of commercialization to growth had been significantly reduced. For example, all of the following product categories moved from introduction to growth in under five years: cellular phones (3 years), CD players (2 years), camcorders (1 year), and direct broadcast satellites (5 years) (Golder & Tellis, 2004). And in 2014 five years represented the full life expectancy, from adoption to obsolescence, most consumers associated with electronic goods (i.e., televisions, smartphones, laptops, etc.) (Ely, 2014).

The short life expectancy associated with products in today’s marketplace means that companies must release new products at an ever-faster pace. A study published in the late 20th century highlighted the dramatic reduction in the time necessary to develop new products (Griffin, 1997). In a cross industry comparison Griffin reported that Honda reduced its new product development cycle for cars from 60 months to 36. General Electric cut the new product development period for jet engines nearly in half, moving from 84 to 48 months. While both Mattel and Hewlett-Packard were successful in reducing new product development phases by more than half for toy cars (18 months to 5) and printers (54 months to 22), respectively. Honeywell dramatically shorted its new product cycle for thermostats moving from 48 months to just 10.

The data related to product life cycles underscores the fact that we now live in an era of innovation, which in very practical terms means that it won’t be long before the latest technological gadget you bought is going to feel antiquated. According to economist Janszen (2000) we moved into the innovation age in the late 1990’s. Around the same time Janszen made his claim, Kelley (2001), of the now well-known design firm IDEO, published a book called The Art of Innovation in which he reported:

*The biggest single trend we’ve observed is the growing acknowledgment of innovation as a centerpiece of corporate strategies and initiatives. What’s more, we’ve noticed that the more senior the executives, the more likely they are to frame their companies’ needs in the context of innovation. (p. 3)*

Both Janszen and Kelley’s observations about the age of innovation were verified by a McKinsey (2008) study that revealed more than 70% of senior executives believed that innovation would be among the top three drivers of growth in their companies (Barsh, Capozzi, & Davidson, 2008). Similarly, Vardis and Selden (2008) found that 75% of the companies they surveyed had innovation ranked among their top three strategic directions. And the great recession did not diminish the perceived need for innovation. A global study of senior leaders in 2010 revealed that 84% of the 2,000 executives surveyed believed innovation was very important for the continued growth and survival of their organizations (McKinsey, 2010).

The changes in our world context across the 20th century and into the 21st century, from an industrial world to a knowledge world to an economy driven by innovation, impacts the types of skills necessary for success in the workplace. Both business and educational leaders have given a great deal of thought to the kinds of skills that predict success in the 21st century, and one skill set that has been consistently identified is creative thinking.

**Thinking Skills Required for Success in the 21st Century**

In the early 1990’s expenditures related to the knowledge age surpassed the industrial age (Trilling & Fadel, 2009). Not surprisingly, this was also the time when reports and studies on the skills necessary for success in the modern workplace began to highlight the importance of creative thinking. It is to be
expected that as the work context evolves, so must the skills necessary for success in that context. In an industrial world the focus was on efficiency, repeatability, predictability, and carrying out tasks exactly as prescribed. While still valuable, in an economy steeped in innovation and change, these same skills began to be overshadowed by a new set of skills. Workplace skills must reflect the spirit of the times, and indeed the trends clearly show how creativity and creativity-related skills have come to the fore in the age of innovation. Table 1 provides a summary of various reports that feature the skills most necessary for success in the workplace. Each of the nine reports featured in this table, most of which were based on surveys and interviews with employers, include skills associated with creativity (creativity-related skills are denoted in bold). Beginning with the 1990 book *Workplace Basics*, and stretching over a 25-year period, these national reports show great consistency with the inclusion of creativity or creativity-related skills in every list.

The most recent list produced by a Bloomberg/Businessweek (Otani, 2015) survey of 1,320 recruiters revealed that 42% of recruiters identified Creative Problem Solving as a highly desirable skill among job applicants. The last column on the right of Table 1 presents the Bloomberg/Businessweek survey in rank order based on the percentage of the MBA recruiters who identified that particular skill among the five skills each considered to be most important. Besides Creative Problem Solving, other skills that have been associated with creativity (see Puccio, Mance & Murdock, 2011) were perceived as being highly important by these MBA recruiters (i.e., Strategic thinking 53%, Leadership 50%, Adaptability 29%, and Risk-taking 20%). What is concerning is that these recruiters identified three creativity-related skills as being the most difficult to find among job applicants. Specifically, 47.3% said it was hard to find applicants who possessed Strategic Thinking, closely followed by Creative Problem Solving at 44.4% and Leadership skills at 42.2%. Taken together, it would seem that while creativity-related skills are in high demand in the innovation economy, educational systems have appeared not excel at developing these high-demand work skills.

The numerous reports found in Table 1 certainly highlight the fact that creativity-related skills are deemed important by prospective employers, but even a more crucial consideration may be the fact that a bulk of the jobs that will be available to humans in the future are those that require creative thinking. Frey and Osborne (2013) developed a formula that predicts the probability that a particular job will become computerized. These Oxford University researchers applied their rigorous methodology to 702 different occupations. Table 2 presents the results for 20 occupations analyzed by Frey and Osborne. The right column provides an illustration of occupations that were determined to have a greater than 95% probability of becoming automated, while the right column shows a sampling of occupations that were determined to have a 1% or less likelihood of being computerized. One of the crucial variables that determined whether a job was future proof was the degree to which that job involved creative intelligence. In fact, creativity was a stronger predictor of jobs that were at low risk of automation than manual dexterity, finger dexterity, and social intelligence. As these researchers concluded, “Generalist occupations requiring knowledge of human heuristics, and specialist occupations involving the development of novel ideas and artifacts, are the least susceptible to computerization” (p. 40).

**INTERNATIONAL CENTER FOR STUDIES IN CREATIVITY: MISSION**

Founded in 1967 at Buffalo State (The State University of New York), the International Center for Studies in Creativity (ICSC) is an academic unit whose purpose has been to provide undergraduate and
### Table 1. Review of Skills Necessary for Success in the Workplace

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</thead>
<tbody>
<tr>
<td>• The Foundation - Knowing how to learn</td>
<td>• Competence – Listening and oral communication</td>
<td>• Adaptability – Creative thinking and problem solving</td>
<td>• Personal Management – Self-esteem, goal setting, etc.</td>
<td>• Group Effectiveness – Interpersonal skills, negotiations, team work</td>
<td>• Influence – Organizational effectiveness and leadership</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Knowing more about the world</td>
<td>• Thinking outside the box</td>
<td>• Becoming smarter about new sources of information</td>
<td>• Developing good people skills</td>
<td>• Critical thinking &amp; problem solving</td>
<td>• Collaboration across networks &amp; leading by influence</td>
<td>• Agility &amp; adaptability</td>
<td>• Initiative &amp; entrepreneurialism</td>
<td>• Effective oral &amp; written communication</td>
</tr>
</tbody>
</table>

Note: Citations for sources were presented at the references section with an asterisk (*).
International Center for Studies in Creativity

Table 2. Future proof occupations

<table>
<thead>
<tr>
<th>95% Probability of Computerization</th>
<th>1% Probability of Computerization</th>
</tr>
</thead>
<tbody>
<tr>
<td>Telemarketers</td>
<td>Recreational/Occupational Therapists</td>
</tr>
<tr>
<td>Tax Preparers</td>
<td>Dietitians &amp; Nutritionists</td>
</tr>
<tr>
<td>Insurance Underwriters</td>
<td>Psychologists</td>
</tr>
<tr>
<td>Umpires, Referees, Sports Officials</td>
<td>Choreographers &amp; Music Composers</td>
</tr>
<tr>
<td>Tellers</td>
<td>Elementary School Teachers</td>
</tr>
<tr>
<td>Restaurant Hosts/Hostesses</td>
<td>Human Resources Managers</td>
</tr>
<tr>
<td>Cooks</td>
<td>Anthropologists &amp; Archeologists</td>
</tr>
<tr>
<td>Drivers</td>
<td>Coaches</td>
</tr>
<tr>
<td>Locomotive Engineers</td>
<td>Interior Designers</td>
</tr>
<tr>
<td>Nuclear Power Reactor Operators</td>
<td>Industrial &amp; Mechanical Engineers</td>
</tr>
</tbody>
</table>

graduate students with the creativity skills in such demand in the 21st century. Our mission statement is as follows (ICSC, 2015):

The International Center for Studies in Creativity credentials creativity through diverse programs that cultivate skills in creative thinking, innovative leadership practices and problem solving techniques. ICSC provides tools that enable individuals, worldwide, to develop their own and others’ creativity to foster positive change.

The diverse programs referred to in this mission statement include both credit-bearing educational programs and non-credit professional experiences. With respect to formal educational programs, the ICSC offers undergraduate and graduate curricula that are discussed more in detail in the section that follows.

ICSC, to our knowledge, was the first educational institution to offer a graduate program specifically focused on creativity. Today, ICSC has over 600 alumni from the Master of Science in Creative Studies and the Graduate Certificate in Creativity and Change Leadership programs. As an international center these former students can be found around the globe. In fact, given its international appeal the ICSC has led the way in leveraging distance-learning technology to make its graduate programs available to anyone in the world. To better understand the structure and content of the ICSC graduate programs, as well as how these courses address and promote the 21st century creativity skills referred to previously, the following section closely examines our graduate curriculum.

A Graduate Program in Creativity: Seminal Roots of an Academic Program in Creativity

The seeds for a university-level academic program in creativity can be traced back to Alex Osborn’s (1953) seminal work in advertising in the early to mid 20th century. The developer of brainstorming and a deliberate creative-process model, called Creative Problem Solving (CPS for short), he successfully integrated his creative methods into the business world and expressed the need for more creativity in education. He articulated his desire to bring a more creative trend to education in his book The Creative
Education Movement (as of 1964) (Osborn, 1964) where he described the need to incorporate creativity into existing courses, as well as offer separate courses on CPS.

Osborn teamed up with Sidney Parnes to further develop the CPS process through the Creative Education Foundation’s Annual Creative Problem Solving Institute and through the development of university-level courses. Parnes, along with Ruth Noller, further developed these courses by creating a sequence of undergraduate academic courses in creativity in 1967 at Buffalo State. Later they developed graduate-level creativity courses and launched the Master’s Degree in Creativity Studies in the mid-1970s. In 1969, their collaboration led to a comprehensive experimental study on the impact of a sequence of four undergraduate creativity courses (Parnes & Noller, 1972; Reese, Parnes, Treffinger, & Kaltzounis, 1976). Perhaps one of the most comprehensive and rigorous investigations of creativity training, the Creative Studies Project provided some of the earliest evidence that university creativity courses significantly improved cognitive abilities deemed important to creative performance.

Diverse Offerings in Creativity

Today, the International Center for Studies in Creativity offers four distinct academic programs in creativity. Our academic programs include an undergraduate Minor in Creativity Studies, an undergraduate Minor in Leadership, a State University of New York (SUNY) Certificate in Creativity and Change Leadership and a Master of Science in Creative Studies. Table 3 provides a summary of the number of courses and credit hours associated with each program.

The undergraduate minor programs are available for students enrolled in all majors (i.e., degree programs). At the undergraduate level, students seeking degrees from the four schools (School of Arts and Humanities, School of the Professions, School of Education and the School of Natural and Social Sciences) can choose to minor in either creativity or leadership (or both). It should be noted, that students do not need to minor in these programs to take advantage of these courses. The introductory level courses are made available to all Buffalo State students.

The Creative Studies Minor provides students with deliberate creativity tools, techniques, and strategies that are equally applicable to their professional and personal lives. They gain expertise in facilitating creative problem-solving teams, managing diverse groups, and creating an environment that nurtures creative thinking. The Leadership Minor program serves as a nexus for connecting and integrating the insights of a variety of disciplines in understanding the complex phenomenon of leadership. Students are introduced to a range of leadership theories and models, and course assignments and activities focus on fostering practical skills associated with leadership competence. Additionally, given the ICSC’s thought leadership in connecting creativity to leader effectiveness (Puccio, Mance & Murdock, 2011), special emphasis is given to the various ways in which creativity practices help to inform leadership.

Table 3. Four academic programs at ICSC

<table>
<thead>
<tr>
<th>Undergraduate Minors</th>
<th>Graduate Programs</th>
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<tbody>
<tr>
<td>Creative Studies</td>
<td>Leadership</td>
</tr>
<tr>
<td>18 Credit Hours</td>
<td>18 Credit Hours</td>
</tr>
<tr>
<td>(6 courses)</td>
<td>(6 courses)</td>
</tr>
<tr>
<td>SUNY Certificate: Creativity &amp; Change Leadership</td>
<td>Master of Science in Creative Studies</td>
</tr>
<tr>
<td>18 Credit Hours</td>
<td>33 Credit Hours</td>
</tr>
<tr>
<td>(6 courses)</td>
<td>(11 courses)</td>
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</table>
These undergraduate minor programs are designed to provide students in any Bachelor’s degree program with the creativity and leadership skills that will make them more marketable and effective in today’s workforce. While a great complement to any degree program, as creative-thinking and leadership are valued in all professional arenas, students studying Business, Communications, Technology, Psychology, and Criminal Justice are among those most likely to pursue the minor programs offered by the ICSC.

ICSC’s graduate programs, the SUNY Certificate in Creativity and Change Leadership and the Master of Science in Creative Studies, attract students from a diverse range of academic and career backgrounds. The program has alumni who are practicing educators and educational administrators, military personnel, entrepreneurs, consultants and trainers, social workers, full-time parents, artists, psychologists, professors, nurses, lawyers, priests, engineers, managers, and not-for-profit administrators. Some of the unique occupations held by our alumni include humorist, professional clown, outdoor education leader, toy designer, inventor, improvisation trainer, artistic director of a theatre company, and philanthropist. At present, of the more than 80 students enrolled in ICSC’s graduate program 26% are internationals. With the exception of Antarctica, students have come from all continents. Many are professionals with decades of experience and in some cases they have already earned advanced degrees, such as Master’s of Business Administration and various doctoral degrees.

All applicants to ICSC’s graduate programs, in addition to other admission criteria, are required to write a letter of intent in which they explain why they wish to earn a Master’s degree in creativity. Unlike more traditional graduate programs, where the reasons for applying might be more apparent, a certificate or Master’s of Science degree in creativity requires an initial understanding of the nature of creativity and how creativity might enhance students’ professional and personal goals. This part of the review process for acceptance into the program provides important information as to the degree of fit between the student and the curriculum.

To provide some insight into the diverse backgrounds, expectations and future aspirations of our graduate students, we share a few quotes extracted from letters of intent submitted by four graduate program applicants. An international student who was an aerospace engineer, for example, expressed his future goals in the following way:

*I want to integrate and use as much tools and concepts as possible. I will use it in my daily reality at work, specifically in project management... and help organizations and higher management of Fortune 500 companies to become more effective and innovative by using tools and techniques learned during my Master’s degree. I’m also aiming to develop partnerships with a network of consultants across North America and Europe, that will give me the opportunity to work with different cultures and contexts.*

A former business owner and school board member who decided to become a high school educator eight years before applying to the Master’s degree program described how the education system should “teach students to think creatively, solve real problems and challenge their perceptions.” A university faculty member, who in a former career managed multi-million dollar advertising budgets, shared a similar passion for creativity in education:

*As individuals, thinking is our core competency. Nothing defines us more than our ability to consider, evaluate and resolve issues. The way we think, how we view and solve problems, becomes our competitive advantage. As Advertising Professors, teaching students to understand the way they think, and how it has been developed through their learning years, is paramount to encourage change in their thought process.*
Providing them with the cognitive tools they need to succeed, change their creative flow process from linear, logical thinking to a more open, creative arena. Success in advertising is dependent on imaginative thinking, inspired through brainstorming activities, in order to develop original campaign concepts.

As a final example, an organizational development practitioner described how the inclusion of creativity practices might expand opportunities both inside and outside of her organizational development practice. As an aside, the sense of wonder and openness to ambiguity expressed in the following passage is a core characteristic of highly creative individuals.

It is one thing to facilitate change and it is another to provide individuals with the insight, tools and techniques so they can identify and initiate growth within themselves or their organization. I do not know yet what this shift from facilitating to empowering looks like. Perhaps it will lead me on a path as an organizational coach, therapist, career advisor/coach or a role my mind has not yet imagined. But I am excited to see how it unfolds and realize in order to reach this goal I need to continue my own learning in the fields of change and development.

Graduate Level Study in Creativity: Overview of the Certificate Program

The State University of New York sanctioned certificate in Creativity and Change Leadership is an 18 credit-hour graduate-level certificate. Approved in 2001, this six-course graduate program is made available to both those who wish to study on campus and those who prefer to complete the certificate as a distance student. Distance students take two residential courses in an intensive summer institute in Buffalo (i.e., two weeks), followed by online courses during the fall and spring semesters, and conclude the certificate program with another summer institute. Campus-based students take most, if not all of their required courses in a seated or hybrid format. As all of the certificate courses can be applied towards the Master of Science Degree, most certificate students go onto complete the full degree. The course structure of the SUNY Certificate is provided in Table 4.

Master of Science in Creative Studies

The Master of Science in Creative Studies, approved in 1975, requires a total of 33 credit hours (i.e., 11 courses) and is broken into three blocks of courses: required, culminating experiences, and electives. The degree contains seven required courses (each course is three credits). Students must select one culminating experience that ranges from zero to six credit hours: a comprehensive examination and portfolio review.

Table 4. SUNY certificate in creativity and change leadership: course overview

<table>
<thead>
<tr>
<th>Required Courses (15 credits)</th>
<th>Elective Course (3 credits)</th>
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| CRS 559 Principles in Creative Problem Solving | CRS 625 Current Issues in Creative Studies OR CRS 670 Foundations in Teaching and Training Creativity
| CRS 560 Foundations of Creative Learning | CRS 580 Creativity Assessment: Methods and Resources |
| CRS 610 Facilitation of Group Problem Solving | CRS 635 Creativity and Change Leadership |

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International Center for Studies in Creativity

(0 credits); a master’s project (3 credits); or a master’s thesis (6 credits). Depending on the culminating experience selected, this will leave the student with a range of 6-12 credits for the elective courses. The Master of Science Degree is offered both to local students as well as distance students. Additionally, in collaboration with the Center for the Development of Creative Thinking (COCD, Belgium) and King Willem I College (The Netherlands), both the Graduate Certificate and Master’s degree programs are available to a European-based cohort of students. Required courses are as follows:

- CRS 559 Principles in Creative Problem Solving
- CRS 560 Foundations of Creative Learning
- CRS 580 Creativity Assessment: Methods and Resources
- CRS 610 Facilitation of Group Problem Solving
- CRS 625 Current Issues in Creativity Studies
- CRS 635 Creativity and Change Leadership
- CRS 670 Foundations in Teaching and Training Creativity

Within the Master’s Degree curriculum, the required courses in addition to the culminating course, are organized into three strands. Each strand represents a distinct approach to the field of creativity studies, and reflects an integration of theory, application, and research. These strands, and their related courses, are outlined in Table 5.

**Overview of the Foundations of Creativity Strand**

The *Foundations of Creativity Strand* surveys various approaches, models and theories useful in understanding the nature of creativity and creative behavior. Although understanding scholarly creativity literature and knowledge, both historically and current, is a focus of this strand, this intellectual pursuit is underscored and reinforced through applied-learning experiences that also serve to build leadership capacity. Students grow in their ability to articulate their original views of creativity, their philosophy

<table>
<thead>
<tr>
<th>Table 5. Required courses in the M.S. in creative studies by strands</th>
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<table>
<thead>
<tr>
<th>Foundations of Creativity Strand (9 credits)</th>
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<tbody>
<tr>
<td>CRS 560 Foundations of Creative Learning</td>
</tr>
<tr>
<td>CRS 625 Current Issues in Creative Studies</td>
</tr>
<tr>
<td>CRS 635 Creativity and Change Leadership</td>
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<table>
<thead>
<tr>
<th>Creative Problem Solving &amp; Facilitation Strand (9 credits)</th>
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<tbody>
<tr>
<td>CRS 559 Principles in Creative Problem Solving</td>
</tr>
<tr>
<td>CRS 610 Facilitation of Group Problem Solving</td>
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<tr>
<td>CRS 670 Foundations of Teaching and Training</td>
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<table>
<thead>
<tr>
<th>Research, Development &amp; Dissemination Strand (Varies from 3 to 9 credits)</th>
</tr>
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<tbody>
<tr>
<td>CRS 580 Creativity Assessment: Methods &amp; Resources</td>
</tr>
<tr>
<td>Culminating Experience Choices (student selects one):</td>
</tr>
<tr>
<td>• CRS 795 Master’s Thesis (6 cr.)</td>
</tr>
<tr>
<td>• CRS 690 Master’s Project (3 cr.)</td>
</tr>
<tr>
<td>• Comprehensive Exam &amp; Portfolio Review (0 credits)</td>
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</table>

<table>
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<tr>
<th>Elective Courses (Varies from 6 to 12 credits)</th>
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<tbody>
<tr>
<td>Student select from courses department, other courses at Buffalo State and/or other accredited higher education institutions in consultation with academic advisor.</td>
</tr>
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</table>
and vision for themselves as creativity professionals through an informed understanding of the historical foundations of creativity studies. Students are poised to contribute to the creativity field’s scholarly conversation through the foundation strand. The required courses in the strand are identified in Table 5.

The first two courses, CRS 560 and CRS 625 can be taken in sequence or simultaneously. The third course, CRS 635 is the capstone course and is taken at the end of the Master’s program. A few of the key workforce skills focused on in this strand include building curiosity and imagination, as well as flexible thinking and creative-leadership skills.

The first core course in this strand, CRS 560 *Foundations of Creative Learning*, focuses on theories and research that serve as a conceptual foundation to the discipline of creativity studies. Students develop an overall understanding of basic principles, as well as historical definitions, models and theories that laid the groundwork for the current field of creativity. One goal of the course is for students to understand the integrated function among key historical definitions, principles and constructs in the discipline of creativity.

The second core course in this strand, CRS 625 *Current Issues in Creativity*, is an in-depth analysis of current research and theoretical perspectives related to the nature and nurture of creativity. Students engage in skill development in research and scholarship to increase critical-thinking skills and general content literacy relative to creativity scholars in various disciplines, interpret findings from empirical and non-empirical sources, and articulate their analysis of a big question in the field of creativity. In fact, the department selects annually the best student papers that are then published in a volume of first works called *Big Questions in Creativity* (see, for example, Culpepper & Burnett, 2015). Some of the course goals include: identify major contemporary scholars in the field of creativity studies; and articulate current trends, gaps and issues in the field.

The third core course in this strand, CRS 635 *Creativity and Change Leadership* is not only the last course in this strand, it is also the capstone course for the Master’s program. The course focuses on understanding and applying the characteristics of change leadership in the context of creativity and Creative Problem-Solving. Students focus on the dynamics of leading change, as well as an examination of key creativity scholars and their areas of interest and philosophical perspective on creativity. The course provides a theoretical and practical launching point for students to examine their future contributions to the field, domain, and discipline. One of the main learning objectives of the course is for students to develop their own unique personal philosophy, values, theoretical foundations and definition of creativity and to develop a future image of themselves as creative leaders in their professional arena, community and in their personal lives. Towards that end, all students are required to submit a paper that captures their philosophy of the nature and nurture of creativity, their personal vision for how they will manifest this vision, and a strategic plan for achieving the vision.

**Overview of CPS Process Strand and Brief Examination of CPS**

The *Creative Problem-Solving and Facilitation Strand* emphasizes ways to deliberately foster creative potential by helping the student to learn, apply, and teach specific CPS tools, process frameworks and small-group facilitation techniques. The courses are sequential as the skills in lower level courses serve as a foundation to subsequent courses (see Table 5).

Courses in this strand are based on the more than 60 years of development that ensued Osborn’s introduction of CPS in 1953. Since that time CPS has been one of the most widely researched deliberate creative-process methods and, as such, has undergone a natural evolution into the current version taught
in this strand (see Puccio, Murdock & Mance, 2005 for a review of various CPS models and Puccio, Firestien, Coyle & Masucci, 2008 for a review of the impact of CPS in organizational settings). In this strand students develop mastery of the current version of CPS, referred to as the Thinking Skills Model (see Puccio et al., 2011). By mastery we mean the successful application of CPS at individual, team and organizational levels.

The purpose of this paper is not to provide an in-depth review of CPS, see Puccio et al. (2011) for that; rather, our goal is to offer a sufficient overview to allow readers a basic understanding of the applied-creativity skills our students develop as a result of the courses in this strand. To that end, Figure 1 provides a graphic image of the Thinking Skills Model. Students learn to apply this deliberate creative process, and associated cognitive tools, to their own challenges, as well as how to lead others to breakthrough solutions through the application of this methodology. The hallmark of CPS is the balance between divergent and convergent thinking. Figure 2 shows the balance between the purposeful generation of multiple original alternatives (divergent thinking), learning to go beyond what is already known or familiar, and the selection and development of those novel options that are seen as most promising (convergent thinking).

Here students learn the cognitive skills associated with divergent thinking, namely fluency, flexibility and originality, as well as the affective attitudes that promote effective divergent thinking, most notably how to suspend judgment. The productive balance between divergent and convergent thinking, which has been cited as a crucial development in human evolution (Gabora & Kaufman, 2010), is featured in each step of the process and serves as a foundational skill as a creative person and creative leader.

The first course in the sequence CRS 559 Principles in Creative Problem Solving focuses on introducing students to principles and tools associated with CPS, with an aim at developing mastery at an individual

![Figure 1](image-url)
level. The focus is on learning how to balance and enhance the capacity to engage in both divergent and convergent thinking. To that end, students learn to apply the key creative principles suspending judgment and affirmative evaluation. Goals for the course include: articulating the basic function of process in creative thinking and problem solving, accurately applying divergent and convergent thinking principles, and successfully utilizing CPS on a personal challenge.

The second course in this strand, CRS 610 Facilitation of Group Problem Solving, focuses on advanced strategies for leading small groups through the CPS process; mastery of facilitation techniques and general CPS skill building. Students gain experience as a CPS facilitator, working with clients and resource group members. Some of the goals for this course include: describing a skill set for effective facilitation of small groups, demonstrating facilitative skills in small groups, and the application of specific divergent and convergent tools in group settings.

The third required course in this strand provides practical experience in using principles of creative learning, as well as advanced CPS and leadership strategies designed to facilitate change initiatives. Students engage in both guided practice and independent work in realistic teaching/training situations both within the university setting and outside in educational, business, not-for-profit and organizational settings. Students develop instructional designs and examine ways to modify teaching, training and leading with CPS and creative learning methods in various groups and situations. Some of the goals of the
course include: applying skills needed to facilitate or lead CPS process in real-world settings (both tools and principles); effectively delivering short learning experiences in creativity, leadership and CPS; and using creative climate dimensions to promote cooperative work in a variety of settings.

The applied nature of this strand promotes many, if not all, of the creativity-related skills deemed necessary for professional success in the 21st century (see Table 1). Beyond professional competencies, most students report that experiences in this strand prepare them to more skillfully respond to life's challenges and to become more resilient when impacted by change.

Overview of Research, Development, and Dissemination Strand

In the third strand, Research, Development, and Dissemination, students focus their efforts on demonstrating competence in understanding the science of creativity studies. Analysis of the current scholarly literature serves as a foundation from which students move towards their own original contribution to the field. This is accomplished through the successful completion of one of three culminating experiences (i.e., Comprehensive Examination, Master’s Project or Master’s Thesis). Several specific workforce skills that are developed in this strand include the innovation skills of critical thinking and problem solving, creative thinking as well as opportunity seeking and seeing things in the mind’s eye.

The first course in this strand, CRS 580 Creativity Assessment: Methods and Resources, is the only course that all students are required to take within this strand (see Table 5). CRS 580 provides practical information on creativity assessment tools and methods. This course includes a basic understanding of quantitative and qualitative research principles and a critique of specific measures and methods used to assess creativity in both education and business. Students receive personal feedback on a number of measures and develop a profile of their own creative strengths. Several goals of the course include describing the fundamental issues associated with assessment such as reliability, validity and usability; applying various measurement considerations to a review and critique of methods and inventories used to assess creativity; and interpreting personal strengths through feedback received on creativity-related measures.

The three options for completing this strand include Comprehensive Exam, Master’s Project(CRS 690) or Master’s Thesis (CRS 795). All three are influenced by the scientific method and include elements of inquiry, synthesis and presentation of findings. The culminating options are designed to provide students with a range of distinct learning objectives, skill development options, and final products. Based on their own interests and goals, students select from one of the three culminating experiences.

The Comprehensive Exam consists of a written review of the literature related to a creativity topic selected by the student, a portfolio review of the products and outcomes generated by the student throughout his or her graduate work, and an oral presentation of the key insights the student gained as a result of his or her Master’s degree work. The comprehensive exam provides students with an opportunity to demonstrate the depth and breadth of their knowledge of the field of creativity studies. Furthermore, the oral presentation provides students with a chance to further refine and explore their vision as creativity professionals.

The CRS 690 Master’s Project requires students to develop and implement an applied project focused on some aspect of their creativity studies related to their areas of expertise and interest. Students can focus in diverse areas of inquiry for their project while they continue to develop their original thinking and analytical skills in the formation and evaluation of the success of the project. Some students use their creative problem solving, change leadership and facilitation skills to implement a change initiative that has a direct impact either on the community or for the field of creativity in general, develop some
aspect of their own specific creative learning and/or formulate products and outcomes that support their
own and/or others’ creativity.

The CRS 795 Master’s Thesis focuses on the design and implementation of an empirical study aimed
at making an original and valuable contribution to the field of creativity. Students focus in diverse areas
of inquiry while they engage in formulating, implementing, evaluating and disseminating an original
study. They gain expertise in utilizing qualitative and/or quantitative research methods as well as analyz-
ing results and formulating conclusions within the context of their study.

Issues, Controversies, Problems

As cited earlier, while numerous business and educational leaders tout the importance of creative think-
ing and problem solving, few educational programs dedicate themselves to these important 21st century
learning outcomes. The ICSC at Buffalo State serves as an example of academic department whose cur-
ricula, both undergraduate and graduate, promote the creativity skills in demand in today’s workplace.
Moreover, we would contend creativity and problem solving are essential life skills. The next section of
this paper examines the impact of the graduate courses, and their content, on our students. As part of the
ongoing assessment work at Buffalo State the ICSC conducted an examination of the degree to which its
graduate courses changed students’ creative attitudes. Puccio et al. (2011) contend that creative problem
solving and creative leadership necessitate mastery of both cognitive and affective skills. To that end,
the purpose of this exploratory study was to determine whether the graduate program contributed to
enhancing attitudes that serve as crucial foundation to effective creative problem solving.

Impact of Graduate Courses in Creativity on the Creative
Problem-Solving Attitudes of Students

The impact of the graduate curriculum that focuses on creativity and creative problem solving was ex-
amined with 60 (Male = 22; Female = 38) students enrolled in either the graduate certificate or Master’s
degree program. The participants represent a broad range of educational backgrounds and work experi-
ences from education to business.

Both qualitative and quantitative data were collected from the participants. Quantitative analyses
focused on attitudes toward ideas. As described earlier, the steps in CPS process are separated into two
major phases of thought: divergent and convergent thinking. In this model (see Figure 2), divergent
thinking precedes convergent thinking in order to ensure that a wide range of alternatives are available
during the selection and development phases of the process. While divergent thinking is generally con-
sidered a cognitive ability, individuals’ attitudes toward ideas can serve to either promote or undermine
this cognitive function. Positive attitudes toward ideas are likely to lead to superior divergent thinking
and ideational productivity (Basadur, Graen, & Green, 1982; Kraut, 1976). Indeed, Dr. Ruth Noller, a
founding faculty member of the ICSC, included attitude as a major driver in her mathematical formula
of creative behavior (cited in Puccio, Mance, Barbero Switalski & Reali, 2012). According to this defini-
tion, creativity is the function of attitudes multiplied by knowledge, imagination, and evaluation. Noller
maintained that the basic factors of creative behavior, that is the interaction of knowledge, imagination
and evaluation, do not reach their full potential without the proper attitudes.

To measure creative attitudes, students completed the Basadur 14 Item Ideation-Evaluation Prefe-
rence Scale at the beginning and end of their respective program of study (i.e., either SUNY certificate
or Master’s degree program). The reliability and validity evidence for this scale was reported by Basadur and his colleagues, see Basadur and Finkbeiner, (1985); and Basadur and Hausdorf, (1996). Basadur’s scale consists of two sub-scales: a six-item preference for ideation and eight-item premature critical evaluation. Both attitudes relate to the key divergent thinking principle referred to as Defer Judgment or Suspend Evaluation. Preference for ideation, specifically, examines the degree to which the respondent is open to novel and diverse ideas. While premature critical evaluation assesses the extent to which respondents report a tendency to quickly criticize original ideas. Basadur 14 Item Ideation-Evaluation Preference Scale was first administered at the beginning of Principles of Creative Problem Solving course (CRS 559), which is the first course the graduate program. The same measure was administered again at the end of the Creativity and Change Leadership course (CRS 635), which serves as the capstone course for both the SUNY certificate and Master’s degree program. To obtain a more detailed perspective on students’ evaluation of the graduate program, they were also asked to reflect on their educational experiences and answer the following questions: “In what ways did your attitudes about creativity change?” and “In what ways did this program impact your growth as a creative person?” Generally there is a full calendar year between the CRS 559 and CRS 635 courses.

The following research questions were explored in this assessment study:

1. Does the academic study of creativity significantly increase preference for ideation?
2. Does the academic study of creativity significantly decrease premature critical evaluation?
3. How does the graduate program impact students’ lives and perspectives in general?

Average scores were calculated for each scale separately and then were compared them before and after the training. Paired-samples t-test was conducted for each scale separately. Qualitative data were transcribed and grouped together based on their thematic similarity.

Quantitative and Qualitative Results

Paired-samples t-test analyses indicated students’ preference for ideation increased significantly, (t(59) = 4.50, p = .001, $\eta^2 = .26$; $M_{pre} = 6.67$, $SD_{pre} = 1.09$; $M_{post} = 7.34$, $SD_{post} = 1.08$) while premature critical evaluation decreased significantly (t(59) = 8.06, p < .001, $\eta^2 = .52$; $M_{pre} = 3.80$, $SD_{pre} = 1.26$; $M_{post} = 2.54$, $SD_{post} = 1.11$). Effect size ($\eta^2$) values, which are considered “large” according to Cohen (1988), underline the fact that participating in a creativity graduate program enhanced positive attitudes toward creativity (i.e., preference for ideation) and decreased negative attitudes (i.e., premature critical evaluation). The change in these two major attitudes after the program are illustrated in Figure 3.

When change in these two attitudes is compared for two scales, a significant change was observed for both in the expected direction but the impact of the program was stronger in decreasing premature evaluation of ideas. This finding indicated that the graduate creativity program seems to be effective in teaching students both what to do, as well as what not to do to be more creative. Ackoff and Vergara (1981) defined creativity as overcoming the self-imposed constraints. The latter could be even more important than the former because creativity is stifled when factors such as cognitive fixation, habits, and blocks remain unchallenged.

Change after training was more closely examined by comparing individual items on the attitude measure, pre and post students’ graduate program. As seen in Figures 4 and 5 as well as Table 6, the largest differences were found in Items 1, 2, 5, 8, 10, and 11. All of these items except item 8 belong to
the subscale associated with premature critical evaluation of ideas. These items state the need for pre-
judgment of ideas, intolerance toward unacceptable ideas, uselessness of wild ideas, and the importance
of quality over quantity whereas item 8 is about embracing others’ wild ideas.

Participants’ answers to the two questions about their own personal transformation with respect to
their attitudes toward creativity and their development as a creative person supported these findings.

Figure 3.

Figure 4.


**Table 6. Mean and standard deviation of individual items**

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*ID: Preference for ideation; **PE: Premature critical evaluation*
Again, the first question asked “In what ways did your attitudes about creativity change?” Naturally this open-ended question revealed a set of attitudes that are more extensive than those examined by Basadur’s measure.

Analysis of the responses revealed several themes. The first theme is application of creativity. ICSC graduate curriculum, by design, is trans-disciplinary in nature. By trans-disciplinary we mean that the content of the curriculum treats creativity as its own domain of study and therefore can be applied to all domains, disciplines, and vocational pursuits. Philosophically this reflects the beliefs held by the founding faculty of the department, as well as the current faculty, that creativity, creative thinking, and creative problem solving are necessary and applicable to all areas of human endeavor. Thus, ICSC’s graduate curriculum emphasizes applied creativity without specifying any field in particular. Commensurate with this philosophical view, students noted that they can apply creativity in both their profession and daily lives. The following sample comments reflect this attitude (initials are used rather than names of the students):

LP: The biggest shift in my attitudes towards creativity is in its application. My scope about creativity has expanded from creative or critical thinking to creative being. I have always known I had a passion for creativity but I did not know how deeply powerful this learning and experience would be.

ND: I have a deeper appreciation for the historical roots of creativity, its diverse background and deeper appreciation for the power of creativity applied in the real world.

Second, students became experts in the field of creative studies and overcame some of the common myths such as art bias (Runco, 2008), which equates and limits creativity to arts.

PP: Creativity does not just belong in the realm of the arts. Creativity involves an expanded understanding of thinking and feeling. Training is invaluable. We are all given the capacity to be creative. Some people need permission, some are told they are not creative, some are fostered to live a creative life with a positive internal or external view of their creativity. It calls for a life. Creativity is a necessity for problem solving. I wish I had it as a kid.

MZ: The answer could go in so many different ways as my attitude has completely evolved. I think my philosophy, newly formed philosophy, sums it up:

- Before program, I believed primarily artists are creative; now I believe we are all creative and it can be fostered
- Before this program, I did not understand and know there are certain skills associated with creativity; now know there are distinct affective and thinking skills for creativity.

AW: Creativity is not just “Big-C”. “Little-C” and everyday C are equally worthy.

JB: I understand it better from a research and academic point of view.

Students also described their personal transformation as a result of their participation in the graduate program. One way to capture their experience is to describe it as a liberating journey.

AW: I am less concerned about “rightness” and more concerned about novelty and uniqueness.

JB: I am here opened to my own creativity. We do not need PhDs to actually go out on the field and talk about it.

TD: I recognize the courage piece. I also see that I just need to use it (courage). I do not have to be right. Every act builds up your creative resilience. Do it for the doing not the getting there. We all
need it. Our sadness (the world) is related to its absence. We all have a right to it. It is a choice to use it or not.

PB: Understand the importance of tolerating ambiguity, complexity in general, and silence during idea generation.
◦ That understanding of self can open you up to creative expression.
◦ Creativity can be taught and inspired.
◦ To stay open and not prejudge, allow ideas to incubate.

Finally, we also found that their attitudes changed in regard to the educability of creativity and their role and function toward this goal.

BW: I have always held creativity in high regard. I tell my students that it is the area of the rubric that I hold most sacred I will grade the hardest. My attitude has changed in how I can convey and teach what creativity is to my students. I was not sure, but now I feel that I have tools, language and process to pass on.

The second question was broader and explored additional ways in which the graduate program impacted their lives. The question was “In what ways did this program impact your growth as a creative person?” Some emphasized that they had greater self-awareness and their belief in self was positively impacted.

LP: I have learned fundamental life lessons through this program. I have realized is much about myself – what holds me back—what gets in my way and how to break through all of that. Beyond the learning I have gained so much from the experience of connecting with all the beautiful—talented creative people in my cohort and within the creativity community.

JB: It has affirmed and strengthened my places of power, uniqueness, and provided a blueprint for moving forward using them.

AW: It has truly been a way for me to identify the “gaps” I have left in my sense of fulfillment and find the right to fulfill…creativity was what I was not acknowledging, I was not brave enough, I needed the tools and now I have them.

TD: I am bare…
My voice matters and has value
Being wrong is as important as being right
Problems correlate to its absence.
We can solve anything we put our minds to
There are so many ways to do, be, and think.
Truly unbelievable journey…
Deep insight. Most incredible learning!
Most fun, most challenge, most growth EVER. Hard too, but in a meaningful way.

They embodied some of the creative characteristics such as tolerance of ambiguity and complexity. They reported becoming more proactive about their own lives. They are more positive, constructive, and solution oriented.

JB: I finally accept the fact that I do not have to fulfill only others’ creativity, but also my own.
I grew up by connecting with other people.
It helped me to reconnect with my heart and my gut.

I am a completely different person – still me but centered and open. I embrace the differences in the world around me. I am part of something greater than myself. I want to inspire this growth in others.

It enhances my creativity and need to spread it to others.
I have clear way to spread creativity, including a “I can solve problems” attitude, tools, and other people to consult and grow with.
I am so much more articulate about how to speak about creativity and how to listen to others’ ideas.
I can be deliberate and even if it is a mistake it serves decision-making and growth.
Know thyself has expanded into, know thyself as a creative person.

Some students’ experiences can be described as transformational. They underlined their change and growth through the program in the following ways.

It has changed my perspective, pushed my growth and broadened my understanding of all facets of creativity.
It has helped give depth and understanding to what it means to be creative, how important it is, and what change can come from being a creative person, not only for myself, but for others that I inspire with my own creativity and the creativity I can inspire within them.
This has been the best experience ……the most practical education directly related to what to do.
It was inspirational, life-changing, and of course educational.

SOLUTIONS AND RECOMMENDATIONS

Like the many thought leaders cited in Table 1, the ICSC faculty believe creativity, creative thinking, and creative problem solving are essential for professional success in the 21st century. Moreover, as life outside of the workplace provides additional challenges and opportunities, we believe that creativity is an essential life skill. With that in mind, the ICSC has set for itself the audacious vision of “Igniting creativity around the world: Facilitating the recognition that creative thinking is an essential life skill.” This vision is achieved, certainly, through engagement with the students enrolled in ICSC’s undergraduate and graduate programs. Students often become future colleagues and join the faculty in creating new programs and products aimed at fulfilling this vision. And as graduates of an educational program in creativity, former students often act as change agents in their respective fields and communities; thereby introducing countless others to the power of creative thinking and creative problem solving (see Fox, in press, for a variety of examples of how ICSC graduates have woven creativity into their professional lives).

To achieve its vision ICSC has looked beyond its own community of faculty, students and alumni. We have entered into partnerships with others to assist them as they form their own creativity programs and initiatives. Perhaps, most notable is the Memorandum of Understanding ICSC has entered into with Sheridan College, Oakville, Canada. Under its new strategic direction Sheridan set a bold objective to
become a creative campus; that is an institution within which all students would have the opportunity to develop 21st century skills. Specifically, Sheridan (2015a) defined its mission as follows: Sheridan delivers a premier, purposeful experience in an environment renowned for creativity and innovation. With creativity and innovation as a priority area within its strategic plan, Sheridan offered the following focus on these crucial skills:

Creativity and Innovation—woven into everything that we do, where teaching, learning, practice and process reflect our commitment to the advancement of creative capacity, creative engagement, collective wisdom, and people success.

Sheridan has turned this strategic aspiration into tangible results. Since 2012 nearly 1500 students have enrolled in a general elective course titled Creative Thinking: Theory and Practice. To both hone creativity skills among students and to provide them with a tangible credential, Sheridan created a board-approved certificate in Creativity and Creative Problem Solving (Sheridan, 2015b). This undergraduate program, which closely mirrors ICSC’s undergraduate minor in Creative Studies, was launched in 2014 and has enrolled nearly 1,000 students in the courses that comprise this certificate. Among other initiatives aimed at fostering a creative culture and campus, Sheridan has trained more than 200 faculty and staff in CPS and has formed a core group of professionals who received advanced training as CPS facilitators. While it seems almost all colleges and university rightfully tout the importance of critical thinking, Sheridan serves as a shining example of an educational institution that has courageously climbed Bloom’s taxonomy of thinking to actively engage its students in the highest level of human thought—Creating.

FUTURE RESEARCH DIRECTIONS

The results of the research findings presented in this chapter focused on the changes in attitudes toward creativity. Allport (1935) defined attitudes as “a mental and neural state of readiness, organized through experience, exerting a directive or dynamic influence upon the individual’s response to all objects and situations with which it is related” (p. 810). Put simply, attitudes precede and direct behaviors. Therefore, the impact of creativity training on other aspects of creativity such as everyday creative behaviors and application of creative thinking skills in the workplace and professional environment needs to be studied. To this end, longitudinal research could be undertaken to reveal the subsequent outcomes. Also, the current study did not include a control group. Inclusion of a control group could reduce the possibility of a Type 1 error.

The programs offered by ICSC have been developed, tested, and evolved over decades. Besides studies that evaluate the programs overall, further studies could explore the usefulness of particular content and tools contained in the curriculum. Such an approach could improve the impact and quality of the courses and programs in the long term.

CONCLUSION

The goal of education should be to prepare the learners for the future. Speed of change and limited predictability of the future requires educators to focus on the crucial life skills that will help learners stay up-to-date, savvy, and adaptive. As summarized in this chapter, creativity is certainly a good example of these important professional and life skills. ICSC offers programs in both graduate and undergradu-
ate levels with an emphasis on applied creativity. This emphasis stems from the premise that everybody has creative potential and creativity is a learnable and improvable skill. The chapter provided evidence from qualitative and quantitative data indicating that the graduate program at ICSC has a transformative influence on students in general and on their attitudes more specifically. What is more encouraging is the fact that other institutions of higher education are now recognizing this impact.

REFERENCES


KEY TERMS AND DEFINITIONS

21st Century Skills: Critical skills needed to be successful in collegiate programs and contemporary careers and workplaces.


Certificate in Creativity and Change Leadership: Eighteen credit-hour graduate-level certificate program sanctioned by The State University of New York (SUNY) that is available to students who wish to study on campus or as a distance student.

Convergent Thinking: Reasoning that brings together relevant information to arrive a valid conclusion.

Creative Attitudes: The way one feels and acts in relation to creativity.

Divergent Thinking: The ability to think in various directions and the capacity to generate many ideas, solutions, and options.

Master of Science in Creative Studies: Thirty-three credit-hour program with three strands namely Foundations of Creativity Strand, Creative Problem-Solving and Facilitation Strand, and Research, Development, and Dissemination Strand.

Ruth Noller (1922-2008): Navy veteran and professors of mathematics and creativity who developed the formulaic definition of creativity in which attitudes are defined as the crucial catalyst for creativity that emerges from the interaction of Knowledge, Imagination and Evaluation.

Sidney Parnes (1922-2013): Academic and former president of Creative Education foundation that developed the Creative Problem Solving and the author of Creative Behavior Guidebook.

Thinking Skills Model: Elaboration and expansion of Creative Problem Solving model with specification of required cognitive and affective skills involved.
Chapter 10
Problem Solving at the Edge of Disciplines

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ABSTRACT

This chapter outlines a new perspective on disciplinary collaboration that draws inspiration from ecology that observes that the edges where ecosystems meet tend to have greater biodiversity than the ecosystems themselves. This thinking is applied to a typical University Faculty consisting of three Schools to show that the potential for collaboration across disciplinary boundaries is rich. The chapter proposes a new degree structure that embeds problem solving skills as core to the production of “pi-shaped” people, defined as those that have disciplinary depth in two areas and the ability to work outside of their core area. In this regard, problem solving is considered an area where a student can achieve depth of knowledge. The degree is designed such that it produces an exchange of students across disciplinary boundaries and also structured so that it takes students on a journey through different models of disciplinary collaboration. The degree is seen as a key enabling of achieving so-called “Mode 2” knowledge production.

INTRODUCTION

Since the industrial revolution, the organization of knowledge into distinct scientific, technical or creative categories has resulted in educational systems designed to institutionalize, reproduce and validate particular occupations or career structures. Typical this results in situations that perpetuate traditional thinking, for example Engineers create Engineering Education, which produces Engineers who reproduce Engineering Education. The methods by which students are exposed to different kinds of education or knowledge are critical in creating and reproducing individual, professional or cultural identities. Today, however, a number of different trends indicate that traditional approaches to education and the formalisation of knowledge needs new approaches. On one hand, the emergence of more open, creative, convergent and socialised technologies – and the entangled, emergent practices arising alongside them – creates
Problem Solving at the Edge of Disciplines

new challenges for traditional discipline-based ways of knowing. Alongside this, there are a growing number of social, economic and environmental problems facing the modern world those fall in to the category of “wicked problems” (Rittel & Webber, 1973). These complex, interconnected problems span disciplines, knowledge bases and value systems and are not tractable to being solved using traditional discipline based thinking (Brown, Harris, & Russell, 2010; Max-Neef, 2005).

This chapter will present the design of an interdisciplinary experience in such a way that it will prepare graduates to take their places in attempting to resolve the challenges presented by the wicked problems facing our global community, both now and in the future. It has been observed that challenges exist in ensuring that students develop sufficient disciplinary knowledge, as simply recombining traditional disciplinary approaches to learning can result in more superficial outcomes as a result of the limited time frame for typical University degrees (Sosa & Connor, 2015). Planning for designing interdisciplinary learning experiences has reached the conclusion that the role of creative technologies programmes should be to produce “T-shaped” thinkers that have both breadth and depth in terms of capabilities (Connor et al., 2016).

The normally held view of “T-shaped” individuals is that they are people possessing functional or disciplinary expertise and the ability to apply knowledge across different contexts (Barile, Franco, Nota, & Saviano, 2012). In this chapter we propose new thinking about the nature of the “T” that is drawn from observations around how undergraduate students can cross boundaries of discipline in an existing interdisciplinary degree, the Bachelor of Creative Technologies. This degree is designed around the use of transformative play spaces (Connor, Marks, & Walker, 2015), which encourage risk taking by embracing “failure” as a positive learning experience (Connor, Berthelsen, et al., 2014) to develop entrepreneurial mindsets in students (Connor, Karmokar, & Walker, 2014).

It has been observed that the most interesting ideas emerge on the boundaries between disciplines that maintain interesting parallels with the concepts of “ecotones” (van der Maarel, 1990) and “edge effects” (Laurance & Yensen, 1991) in ecological systems. By exploring these ideas, we propose the production of a pi-shaped person where there is a dual depth of knowledge. The first of these knowledge areas is related to ideation ability, problem solving skills and creativity, whilst the second is related to a traditional discipline area. In addition, such a person has a breadth of knowledge across different disciplines, but gained in such a way that it does not limit their ability to transcend the normative thinking that accompanies such disciplinary knowledge.

The ability to develop such graduates comes from the potential offered by the Faculty of Design and Creative Technologies at Auckland University of Technology, particularly at the intersection of the School of Art & Design, the School of Communications & Media Studies and the School of Engineering, Computer & Mathematical Sciences. This potential to incubate ideas and knowledge creation draws from the disciplinary “habitats” that exists at the boundaries of the disciplines. As with many ecosystems, this environment that exists on the edges of others is potentially rich in diversity. The goal of the learning experience is to challenge traditional degree structures; to stimulate new forms of connective, imaginative and explorative learning, and; to equip students to creatively and proactively respond to changing career opportunities. Learning is conceived as an emergent process; initiated, realised and self-managed by students through critique and open peer review (Connor, Buchan, & Petrova, 2009).

We note the observation of Meyer and Land who suggest that the dynamic processes of change and the gaining of new insights on the world, initiated through learning, may also involve the “loss” of one’s “old self” or known (disciplinary) identity, for teachers as well as students (Meyer & Land, 2005, pp. 374-375). This positive erosion of so-called “disciplinary egocentrism” (Connor, Karmokar,
Problem Solving at the Edge of Disciplines

& Whittington, 2015; Richter & Paretti, 2009) has the potential to increase the richness of the learning experience between disciplines. This chapter is also the manifestation of the authors’ ongoing search for creative, hypothesis-driven or inquiry-based learning methodologies that address Boyer and Mitgang’s impassioned call for:

*A new educational language ... driven by the conviction that the standards used to evaluate performance should be organized not so much around blocks of knowledge ... as around modes of thinking: the discovery, integration, application and sharing of knowledge (Boyer & Mitgang, 1996, p. 66).*

Operating across and around traditional disciplinary thresholds also afforded an opportunity to explore some practical implications of Hinchcliff’s “post-industrial educational ethics” and such “woolly aberrations” of formal learning processes as “uncertainty, mystery, paradox, chaos, ambiguity, enigma, complexity and doubt” (Hinchcliff, 2006, p. 80). We were particularly interested to see whether, or how, we might accommodate “spontaneously inquisitive, sometimes skeptical, and occasionally quixotic virtues of scholarly inquiry” (Hinchcliff, 2006, p. 81).

We also acknowledge a historical trajectory of learning spaces that seem to hint at a kind of parallel history of threshold concepts; from Dewey’s “continuity and interaction” (Dewey, 1938), Vygotsky’s “active participation in the acquisition of knowledge” (Vygotsky, 1978), Wenger’s components of “meaning”, “practice”, “community” and “identity” (Wenger, 2008) and Abbott’s “ecologies of practice” (Abbott, 2005). Future research will explore the notion of “threshold experience” as transmission of affect (Brennan, 2004) and the ethico-aesthetic tensions created between concepts, people, objects and material (Bennet, 2010). However, our immediate concern here is to argue for the experiential reality of an interdisciplinary and transdisciplinary learning space as a “connected system of thresholds”.

**BACKGROUND**

This chapter is focused on the design of a transdisciplinary undergraduate degree programme that draws inspiration from the concept of an ecotone between ecological systems. The following sections provide an introduction to the concepts of both ecotones and disciplinarity.

**Ecotones and Edge Effects**

In ecology, an ecotone is a transitional zone between adjacent ecological systems, having a set of characteristics uniquely defined by space and time scales, and by the interactions between the adjacent ecological systems (Di Castri, Hansen, & Holland, 1988). Ecotones vary in size and nature, depending on the characteristic of the adjoining ecological systems. For example, an ecotone may be a gradual blending of the two separate ecological systems across a wide area, or alternatively it may manifest itself as a sharp boundary line. The word ecotone was coined from a combination of eco(logy) plus -tone, from the Greek tonos or tension – in other words, a place where ecologies are in tension (Harris, 1988).

Traditionally, ecotones have been associated with increased richness and abundance in as well as the occurrence of unique ecotonal species (Odum, 1953). Odum also suggests that “The tendency for increased variety and density at community junctions is known as the edge effect” (Odum, 1953, p. 278) and “Sometimes ecotones are populated by more kinds and larger numbers of birds and game animals
than can be found in the interior of the adjoining, more homogeneous communities. Wildlife managers speak of this as the edge effect…” (Odum, 1997). Where two overlapping ecosystems exist, it is common to find species from both of these ecosystems along the common edge, as well as unique species that aren’t found in either ecosystem but are specially adapted to the conditions of the transition zone between the two edges.

Figure 1 illustrates the impact of the edge effect on the biodiversity of an ecotone. In this simple illustration, each ecosystem contains only three species, represented by the different colours. The squares are species that belong to the first ecosystem and the circles are species belonging to the second.

The ecotone is the region where the two ecosystems overlap. In this area, there are members of all species from each of the separate ecosystems. The combination of squares and circles (which represent six species) produce unique conditions, which can now support three new species that survive just in the ecotone, represented as triangles. So, while each ecosystem only contains three species, the overlapping transition zone contains nine.

Ecotones therefore typically contain a greater diversity of species than either of the two separate ecosystems as a result of the edge effect, and have significantly greater “productivity”. This occurs for a number of reasons, such as:

- The ecotone allows access to resources from both of the ecosystems.
- Environmental conditions (e.g. air temperature, humidity) are more variable in the ecotone and can create favourable microclimates that can support unique species.
- Increased light levels along the edges that allow more plants to grow resulting in greater diversity and increased productivity.
- Greater diversity of plant life increases the likely diversity of herbivorous insects, which increases birds, and other species higher up the food chain.

Figure 1. Diversity in an ecotone
Ecosystem edges and borders act as ‘energy nets’ that can capture the large movement of energy, nutrients and materials across their boundaries that can exert strong influences on the fertility and productivity of ecosystems.

Whilst these reasons for increased biodiversity in an ecotone do not directly translate into an educational setting, one of the fundamental premises of this chapter is that new educational experiences can be formulated most productively in the overlapping edges of traditional disciplines. This can be borne out to some extent by considering the above points. For example, a researcher undertaking a project that spans two disciplines may have access to research methods (or “resources”) from each discipline that enrich the project. Other such parallels can be drawn with the above reasons that ecotones are so diverse and projective.

**Disciplinarity in Education**

There is a growing body of literature that can be used to identify and explore the academic disciplines, disciplinarity and various forms of cross-disciplinarity (Aboelela et al., 2007; Bremner & Rodgers, 2013). The traditional view of an academic discipline is an area of study “with its own theories, methods and content … [with its] distinctiveness being recognised institutionally by the existence of distinct departments, chairs, courses and so on” (Squires, 1992, p. 202). Historically, academic disciplines have been considered to be largely discrete and autonomous, although not homogeneous (Becher, 1981). Despite many social changes, the nature of academic disciplinarity has remained largely unchanged, save perhaps for the dynamism that disciplines display: growing, morphing and splitting over time (Trowler, 2014).

The notion of a discipline has been defined in many ways. For example, Donald describes a discipline as having “a body of knowledge with a reasonably logical taxonomy, a specialized vocabulary, an accepted body of theory, a systematic research strategy, and techniques for replication and validity” (Donald, 2002, p. 8). The body of knowledge related to a discipline has also been described as providing the foundation to train and socialise members of a faculty (Beyer & Lodahl, 1976). This process develops the ability to carry out the appropriate tasks of teaching, research, and administration that are relevant to the discipline. It promotes the production of relevant research, the process of peer-review, and a system of rewards related to these activities (Beyer & Lodahl, 1976; Reich & Reich, 2006). Disciplines have also been defined as ‘cultural phenomena’ and as such “they are embodied in collections of like-minded people, each with their own codes of conduct, sets of values, and distinctive intellectual tasks” (Becher, 1981, p. 109).

The following characteristics are typical of those commonly used to determine the nature of an academic ‘discipline’:

- The existence of a scholarly community.
- A tradition or history of inquiry.
- A mode of inquiry that determines methods of data collection and interpretation.
- Defining the what constitutes a new contribution of knowledge.
- The existence of a communications network.

Individuals from different disciplines all differ markedly in terms of how they substantiate their knowledge and their methodologies used (Hofer, 2001). Academic disciplines can have significant dif-
ferences in regard to standards of justification and evidence, degrees of certitude in what constitutes knowledge, and in their understanding of the structure of knowledge itself.

Within traditional definitions of academic disciplines, each discipline is considered discrete and autonomous with a well-defined educational progression for students. Whilst there are exceptions, in most disciplines a student undertakes their studies in some form of faculty structure where departments with some common ground offer one or more degree programmes that correlate to a given discipline. This selection of disciplines prior to starting of their study influences a student's opinion about what is known, what is valued, and what is capable of being investigated. The progression of the student through their studies often results in a limited understanding of the context in which their discipline sits. For example, a biology student will only have a relatively limited understanding of physics even though both disciplines are fundamentally related under the umbrella of science. Disciplinarity therefore describes the traditional perception of the academic terrain. It is a term used to describe autonomous and discrete areas of study. Academic disciplines, from this perspective, are discrete ‘boxes’, albeit with boundaries that may be permeable.

This traditional view of academic disciplines does not reflect the changing context of tertiary education. Squires (1992) suggests that the main issue with the traditional notion of academic disciplines is a lack of recognition that disciplines evolve and change over time, with new disciplines emerging and existing disciplines morphing as the body of knowledge associated with them changes. Academic disciplines are therefore both historically and culturally situated.

A number of attempts have been made to redefine the idea of ‘academic discipline’ to accommodate these issues (Becher & Trowler, 2001; Squires, 1992). Squires (1992) defined disciplines in terms of three different characteristics, namely their object, their stance and their mode. The object of a discipline described what the discipline is concerned with in terms of current problems and issues. The stance of a discipline described the current epistemic concerns, so what is considered to be the framework of knowing and how they do things. Finally, the discipline mode is how it reflexively considers itself as a discipline. Many disciplines go through periods of ‘normality’ (that is, business-as-usual using an unchallenged, commonly agreed-upon theoretical framework), to ‘revolutionary’ periods where these frameworks are questioned, thrown into doubt and/or replaced - for example, Einsteinian physics replacing Newtonian physics (Kuhn, 2012).

Squires also suggests all disciplines are “multidimensional spaces in which define, protect and enlarge themselves along any of those dimensions, and in so doing, come into conflict or cooperation with other disciplines” (Squires, 1992, p. 202). The boundary of disciplines is therefore an area where the discipline can be influenced by others, whether that be through the existence of disciplinary tension or friction, or whether it is through the boundary being permeable with new ideas being absorbed from other disciplines.

**Flavours of Multiple Disciplines**

Various frameworks have been developed that attempt to describe and characterise the various modes of interaction between multiple disciplines. For example, Jantsch (1972) describes a set of hierarchical models to describe forms of collaboration that involve alternative disciplines that provides an insight to the disciplinary by making explicit the form of cooperation involved. The hierarchy begins with “multidisciplinary,” the simplest form of work proceeding from the single discipline, and then continues with pluridisciplinary, crossdisciplinary, interdisciplinary, and transdisciplinary. Each term relates to variations in the structure and complexity of group work across disciplines in a hierarchical fashion.
This framework has been expanded by others (Stein, 2007) to include other modes of cooperation, such as metadisciplinary, alterdisciplinary and undisciplinary (Bremner & Rodgers, 2013). The utilisation of all of these terms are at times contradictory, and indeed the term “interdisciplinarity” is notoriously misunderstood (Moran, 2002), so the remainder of this section outlines the definitions used in this study with regards the main forms of inquiry involving multiple disciplines. It is important to make a distinction between true interdisciplinarity and the lesser concepts of multidisciplinarity, pluridisciplinarity and crossdisciplinarity.

These different modes of interaction between disciplines exist on a spectrum that increasingly places them away from disciplinarity. The first mode in this spectrum is multidisciplinarity that in many respects is conceptually no different from disciplinarity. Multidisciplinarity recognises the fact that there are many discrete and autonomous disciplines that may be working alongside each other in a problem-solving environment, though a practitioner in each discipline does not necessarily understand or use knowledge associated with one of the other disciplines. In the context of education, students would normally specialise in one discipline, or perhaps two through either a major/minor structure or a conjoint degree. Many students will have the option to elect to study a number of courses associated with other disciplines. For example, a student majoring in Engineering may also study for a minor in Psychology, and also undertake one additional course in Japanese. However, the learning is self-contained with in the major, minor or course with no information being used across the entire programme of study. Multidisciplinarity has been described more simply as the view that: “everyone [does] his or her thing with little or no necessity for any one participant to be aware of any other participant’s work” (Petrie, 1976, p. 9). Multidisciplinarity is simply the co-existence of a number of disciplines.

The first step towards integration of knowledge across disciplines involves a state of pluridisciplinarity. This requires the deliberate juxtaposition of different disciplines so as to enhance the relationships between them. Communication between disciplines is encouraged but not coordinated and the nature of any integration is therefore, once again, largely a matter of chance (Chynoweth, 2009). In contrast, crossdisciplinarity introduces an element of coordination into the relationship between disciplines. However this occurs where one discipline imposes its own disciplinary concepts and goals on the others by force. Therefore, although coordination is present there is an absence of dialogue and the relationship is more about control then cooperation. Crossdisciplinarity is best considered as when a topic normally outside a field of study is investigated from the context of another discipline. Two examples might be the physics of music and the mathematics of art. Whilst such investigations are often informative and interesting, this mode of inquiry typically involves the use of different tools and techniques normally used to study the disciplinary issue. There is rarely any transfer of methodologies in cross-disciplinary work. Using one of the previous examples, mathematicians don’t necessarily learn any art and artists do not necessarily learn much about mathematics.

The remaining modes of integrating disciplinary knowledge are all considered as variations of interdisciplinarity. While the traditional view regards disciplines as discrete and autonomous, interdisciplinarity recognises the subtleties of the nature of academic disciplines. There are a number of possible forms that interdisciplinarity might take, but there are points of common agreement in terms of the collaboration between disciplines. The different models of disciplinarity are shown in Figure 2.

Some conceptualisations of interdisciplinarity collapse discipline boarders (and a new discipline emerges), while others in fact entrench discipline boundaries and so encourage a mutually radical dialectic-critique of opponent territories (Rowland, 2001). An example of the former would be the overlap occurring between systems engineering, mechanical engineering, electrical engineering, telecommuni-
cations engineering, control engineering and computer engineering that produced the new discipline of mechatronics. There are open questions as to whether the collapsing of discipline boundaries is a positive phenomenon, and indeed whether the creation of new disciplines is beneficial.

This chapter will focus on just two variants, the simplest case of interdisciplinarity and that of transdisciplinarity. Interdisciplinarity is regarded simply as elective subjects taken from a variety of disciplines that in some way relate to a general topic – an example might be care for the ageing population (Hall & Weaver, 2001) that requires both clinical and non-clinical disciplines contributing their particular disciplinary knowledge on a common subject. Unlike multidisciplinarity, where disciplinarians need not necessarily communicate and collaborative with each other, this variant requires “more or less integration and even modification of the disciplinary subcontributions while [an] inquiry is proceeding. Different participants need to take into account the contributions of their colleagues to make their own contribution” (Petrie, 1976, p. 9).

It has been noted that some forms of interdisciplinarity involve the “collapse of academic borders and the emergence of a new discipline” (Davidson, 2004, p. 308; Rowland, 2001). This is sometimes known as ‘transdisciplinarity’ (Max-Neef, 2005), though it is questionable whether a transdisciplinary approach necessitates the emergence of a new discipline. Transdisciplinarity is necessarily based on disciplinary practices. However, it is also based on the assumption that these practices must evolve to match the complexity of the issues facing today’s scientific community (Ramadier, 2004). It is the distinction between interdisciplinarity and transdisciplinarity that causes much confusion. Table 1 highlights some differences between the two gleaned from the literature.

To summarise the outcomes from this comparison, this chapter identified transdisciplinarity as the goal of the educational programmes because of the focus of the need to solve problems collaboratively through an equal exchange of the knowledge and methods from multiple domains.

Petrie (1976) observes from the history of the disciplines that interdisciplinary relationships emerge between disciplinary specialists only when the demands of their subject warrant it, and not before. This typically occurs when a problem or conceptual issues demand new perspectives to provide breakthroughs. These insights can certainly come from different disciplines. There are numerous cases in which the nature of a problem has necessitated the insights of another discipline (Petrie, 1976), and here, interdisciplinarity occurs naturally among disciplinary specialists. One question for the design of a transdisciplinary degree programme is how best to stimulate the need for such collaboration and allow it to emerge.
Table 1. Comparison of interdisciplinarity and transdisciplinarity

<table>
<thead>
<tr>
<th>Definition of Interdisciplinarity</th>
<th>Definition of Transdisciplinarity</th>
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<tbody>
<tr>
<td>Two-level multigoal; coordination from higher level. (Jantsch, 1972)</td>
<td>Multilevel multigoal; coordination of whole system toward a common goal. (Jantsch, 1972)</td>
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<tr>
<td>Interdisciplinary programs start with the discipline. (Meeth, 1978)</td>
<td>Transdisciplinary programs start with the issue or problem. (Meeth, 1978)</td>
</tr>
<tr>
<td>Interdisciplinarity is the transfer of methods from one discipline to another, eventually creating new disciplines. (Nicolescu, 2002)</td>
<td>Transdisciplinarity is ‘at once between the disciplines, across the different disciplines, and beyond all and it encourages an active engagement with real-world problems, a transformative praxis and a constructive approach to problem-solving’. (Nicolescu, 2002)</td>
</tr>
<tr>
<td>Interdisciplinary research can be focussed on a problem, but it is the question of who is involved in the collaborative project that distinguishes interdisciplinarity from transdisciplinarity. (Wickson, Carew, &amp; Russell, 2006)</td>
<td>Three key characteristics that constitutes a transdisciplinary approach to research as distinct from multidisciplinary and interdisciplinary approaches are problem focus, evolving methodology and collaboration.(Wickson et al., 2006)</td>
</tr>
<tr>
<td>An understanding is demonstrated of at least two disciplinary competencies. One is primary, yet it is able to employ the concepts and methodologies of another discipline. Strengthens understanding of the primary discipline. (Bremner &amp; Rodgers, 2013)</td>
<td>An understanding is demonstrated of at least two disciplinary competencies, neither of which is primary. Results in a transmethodological perspective. Abstracts disciplines to bridge new problems. (Bremner &amp; Rodgers, 2013)</td>
</tr>
<tr>
<td>Interdisciplinary research typically involves greater dialogue and collaboration among scientists addressing issues across disciplines over the course of a project. Inter and transdisciplinary approaches are not necessarily exclusive, and at times the terms have been used interchangeably to emphasize efforts designed to identify, capitalize, and leverage expertise from multiple disciplines. (Hunt &amp; Thornsbury, 2014)</td>
<td>As a distinguishing feature, transdisciplinary research further blends disciplinary boundaries to achieve integrative collaboration. The essence of transdisciplinary research requires a synthesis of ideas and methods among researchers with emphasis on a format for conversations and connections that lead to new knowledge. Participants step outside conceptual, theoretical, and methodological confines of their own discipline and develop a shared approach to address the problem under consideration. Scholars involved in transdisciplinary projects must be willing to transcend and integrate disciplinary paradigms with the goal of finding a unity of knowledge beyond individual fields of study. (Hunt &amp; Thornsbury, 2014)</td>
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DESIGNING TRANSDISCIPLINARY LEARNING

The University Ecotones

The Faculty of Design and Creative Technologies at Auckland University of Technology consists of three main Schools, namely the School of Art & Design, the School of Communication Studies and the School of Engineering, Computing & Mathematical Sciences. If each of these Schools is considered an ecosystem in its own right, then there exists the potential for a number of different ecotones to exist, the most diverse of which occurs in the intersection of the three Schools.

For natural ecosystems, there is a degree of fragmentation in a habitat impacts to some degree the impact of the edge effect and the corresponding diversity of the ecotone where that habitat overlaps another. None of the Schools in the Faculty are homogenous and each consists of a number of departments or curriculum areas which creates sub-ecosystems with in each School. In total, there are six departments within the School of Engineering, Computing & Mathematical Sciences, seven curriculum areas in the School of Communication Studies and seven departments in the School of Art & Design. Each of these departments therefore produces a particular “species” of student that adds to the potential richness of
the overlapping ecotone. Figure 3 takes the illustrative example from Figure 1 and populates it with the concept of a student from each curriculum as a species.

Figure 3 shows that potential for ecotones exist between any two of the three Schools that are already rich in terms of diversity, particularly if the inclusion of new “species” of students in this ecotone is catered for. However, there is by far a much greater potential when collaboration education is undertaken in the area that exists across all three Schools. However, the goal of operating in such a diverse space needs to be considered with caution. Chynoweth (2009) suggests that whilst an interdisciplinary experience may be achieved in some institutions it seems likely that most students’ experiences are at best pluridisciplinary. Similarly, Max-Neef (2005) argues that no transdisciplinary universities exist though some interdisciplinary efforts taking place, but mainly as marginal experiences not integrated into the university structure.

*Figure 3. Ecotonal diversity in the Faculty of Design & Creative Technologies*
Problem Solving at the Edge of Disciplines

Planning the Learning Experience

Traditional approaches to planning a student learning experiences across disciplines would consider the use of a major/minor structure or conjoint degrees. However, considering the definitions of inter- and transdisciplinarity presented in Table 1, it is clear that the use of these traditional approaches will not result in an interdisciplinary outcome and that alternative approaches need to be considered. It has been suggested by Max-Neef (2005) that the structure of the great majority of Universities in terms of Faculties and Departments reinforce uni-disciplinary formation and that transformation should occur at the level of postgraduate programmes oriented, whenever possible, around thematic areas instead of specific disciplines. Max-Neef (2005) considers as an example a postgraduate programme in “Water”, which could call together engineers, lawyers, chemists, biologists, agronomists and achieve transdisciplinarity in each of them. This would be achieved because the result would not be the study of water as seen from the perspective of the engineer, or of the agronomist, or of the biologist, but as seen in an integrated manner. The suggestion by Max-Neef (2005) to focus on postgraduate programmes is both logical and reasonable, as to a certain extent it is important to have a base knowledge of at least one discipline to be ready to embrace transdisciplinarity. Yet potential still exists to design transdisciplinary learning experiences for undergraduate students.

Max-Neef (2005) describes a four level hierarchy of disciplinary knowledge with the lowest level being the empirical level. Immediately above is another group of disciplines that constitute the pragmatic level, including, among others, engineering, architecture, agriculture, medicine, etc. The third is the normative level, including disciplines such as planning, politics, design of social systems, environmental design, etc. Finally, the top of the pyramid corresponds to a value level. This hierarchy is shown in Figure 4.

Each level in the hierarchy can be considered as a question, for example at the empirical level we find disciplines that relate to the physical laws of nature and the principles that drive life and societies. This level asks and answers the question “what exists?”. The next level is composed mainly of technological disciplines that answer the question “what are we capable of doing?”. What this level does not tell us, is whether our capacities should be implemented. The danger often is that we do things simply and only because we know how to do them. The normative level asks and answers the question “what is it

Figure 4. Hierarchy of disciplines
Adapted from Max-Neef (2005)
we want to do?”. The value level asks and answers “what should we do?” or rather “how should we do what we want to do?”.

Max-Neef (2005) describes interdisciplinarity as a collaboration between two levels of the hierarchy, whereas transdisciplinarity is a collaboration across all four levels driven by the value level. It is questionable whether a typical undergraduate student has the capacity to approach a transdisciplinary project from this starting point, however it is possible to design a learning experience that is driven by the normative level from which the value level is later addressed.

Initiating a learning experience from the normative level requires a shift in thinking when considered from a perspective of the ectones that exist between disciplines. Though natural to do so, it is not sufficient to ask questions along the lines of “What problems can be solved by a team of students from Fashion Design, Journalism and Computer Science?”. Instead it is more important to identify a suitably challenging problem and present it the students that may be present and see what solutions can be explored given a particular depth and breadth of disciplinary knowledge. For this to be successful, it is important that students develop skills in creative problem solving that transcends their disciplinary base knowledge.

Pi-Shaped People

The ability to tackle complex problems across disciplines requires the production of “T-shaped” people. This implies that a person has depth of disciplinary knowledge but with a broad awareness of other disciplines that allow them work outside of their core area (Allenby, 2011), as shown in Figure 5.
Whilst a number of authors have identified variations of “T-shaped” people, the idea of alternating the breadth and depth aspects of the T are considered to be an area left for future exploration (Simpson, Barton, & Celento, 2008).

Taking into account the view of Bremner and Rodgers (2013) that a transdisciplinary designer would exhibit disciplinary competencies in at least two areas, our approach to rethinking “T-shaped” people is to focus on the so called “pi-shaped” person (Allenby, 2011), noting that the Greek letter π bears resemblance to double stemmed T. However, rather than exhibiting competence in two disciplines one of the stems represents a depth of knowledge and capability in problem solving. Our “pi-shaped” person therefore is a competent and creative problem solver, has depth of knowledge in a discipline and the ability to transcend disciplinary boundaries.

**Problem Solving in the Curriculum**

The challenge of developing “pi-shaped” people in an undergraduate programme is non-trivial; however developing the depth in problem solving ability in a progressive manner is key to its success. Depending on the nature of the environment, this can be addressed in a number of ways. For example, it is conceivable to bring together final year students in a project environment where they work collaboratively under the supervision of a transdisciplinary-capable staff member. In this way, students are encouraged to share their disciplinary approaches and apply them to different problems and in doing so reflect upon and modify their disciplinary knowledge.

An alternative approach may be the development of a Minor (or Major) that exists within the University that enables students to learn different problem solving skills over a longer period of time in parallel to developing their disciplinary knowledge. This approach has the advantage that students are exposed to different ways of thinking that may prevent the onset of disciplinary egocentrism. Potentially, such a Minor could be offered as a single semester immersive experience.

A final option to consider would be the design and delivery of a dedicated transdisciplinary degree. These options are of course not mutually exclusive and the preferred approach would be to deliver a transdisciplinary degree as the backbone of the student learning experience, which offers both a Minor that is attractive to students enrolled in discipline-based degree programmes. This has the potential to create multiple touch points throughout a three-year degree, culminating in a capstone project experience that draws together students from multiple disciplines into a transdisciplinary projects. This approach allows creative problem solving to be firmly embedded in the transdisciplinary degree in a progressive manner, and for the students in this programme to be the “glue” that holds together the fragmented habitat of the ecotone between the Schools.

One of the main reasons that the focus on transdisciplinarity in postgraduate programmes is the assumption that an undergraduate needs to develop some disciplinary depth in order to then develop a transdisciplinary capacity. However, it is possible to challenge this by articulating the learning journey as a progression from multidisciplinarity through crossdisciplinarity and in to inter- and trans-disciplinarity. This can be achieved in a three year degree programme by focusing the first year on multidisciplinary projects, the second year on cross disciplinary projects and the final year on interdisciplinary projects culminating with a transdisciplinary capstone project.

The manner in which this can be integrated into a degree programme will be illustrated using a typical structure of degrees at Auckland University of Technology. A Bachelors degree is considered to be 360 points of study, completed over six semesters typically of 60 points of study each. These are normally
Problem Solving at the Edge of Disciplines

distributed into either 15-point or 30-point modules. Within this framework, a Major consists of achieving 120 points from specified modules and a Minor consists of 60 points. Figure 6 illustrates a structure of modules that integrates the strategies of utilising a specific degree as the backbone of transdisciplinary education, with linkages across multiple degrees using the Major/Minor structure.

This degree structure encourages the movement of students across institutional boundaries at all levels of study by encouraging students enrolled in the degree to take up to 120 points of their study from other programmes. This allows a student to gain a Major in a specific discipline area that may be Software Engineering, Digital Media or so on. This is complemented by a focus in the degree on problem solving ability, integrative thinking and a structured progression of learning from multidisciplinary through to transdisciplinary projects.

Meanwhile, the degree also promotes the exchange of students from other degrees by allowing students to obtain a Minor in Creative Problem Solving or a Major in Transdisciplinary Thinking. These are facilitated by the creation of smaller elective papers that are embedded in the project experience of the degree.

This two-way flow of students in and out of the degree has clear benefits in terms of developing “pi-shaped” people. A graduate of the degree will obtain both depth of disciplinary knowledge through their external Major and depth in problem solving and integrative thinking through the core of the degree. They obtain an understanding of how to work across a breadth of disciplines by interacting with students from other programmes whilst working through the structured transition of projects.

Figure 6. Degree structure
Embracing Transdisciplinarity

The abstract programme presented in Figure 6 offers the possibility of leading students on a journey from multidisciplinarity through to transdisciplinarity. This can be enhanced through adopting a vertical orientation that integrates students at different stages of their study into projects in different ways. Such vertical orientation has been highlighted as a strategy that promotes the ability for students to learn from each other (Connor, Karmokar, et al., 2015) as well as engaging with unique projects that blur traditional boundaries between undergraduate study and staff research projects (Connor & Gavin, 2015; Foottit, Brown, Marks, & Connor, 2014). However, the design of projects and the overall progression of projects needs to be carefully considered so that such vertical orientation is meaningful.

The authors of this chapter all come from different disciplines, namely engineering, industrial design, media studies and computer science. We draw upon our disciplinary diversity to indicate how a single thematic project could be presented to all students in the first semester so that it presents opportunities for students to work in multi-, cross- and interdisciplinary manners. In this example, we propose a thematic concept of “water” as suggested by Max-Neef (2005).

First year students would be expected to engage with the theme of water in a multidisciplinary fashion. This might include the conduct of a project that is conducted in parallel with other projects, for example, the production of a film about water could be pushed from a media studies disciplinary perspective by one group of students whilst another group learns about the distribution of water from an engineering perspective.

Second year students would need to adopt a crossdisciplinary approach to the thematic project, this would typically be where one disciplinary perspective drives a project that utilises other disciplinary knowledge on the same hierarchical level (see Figure 6). As a specific example, this could involve the development of computer-based models that that predict water use in agricultural situations. Students would be expected to learn about agriculture in such a way that the knowledge may be used in the development of the computer application.

Third year students undertake an interdisiciplinary project that by definition needs to bridge multiple levels of the discipline hierarchy presented in Figure 6. A project might be the conduct of a design exercise to determine the best solution for capturing and distributing rainwater in countries that need more stable agriculture. This in essence creates an umbrella to all the projects being conducted, so that the students in the second year developing predictive models do so to inform the design project. Students in the first year utilise their engineering knowledge to support design decisions to work out the most efficient water distribution methods and the film is produced about the plight of water shortage in the area under consideration.

Such an approach produces an integrated learning experience that is quite unlike the traditional experience of a university degree. The strategies for introducing creative problem solving skills in such an experience are discussed in the next section.

Strategies for Developing Creative Problem Solving Skills

Problem-solving, as commonly taught in schools, is an analytical or procedural approach. This approach almost exclusively employs left-brain thinking modes, is competitive, and relies on individual effort. However, creative problem solving is a framework that encourages whole-brain, iterative thinking in the
most effective sequence; it is cooperative in nature and is most productive when done as a team effort (Lumsdain & Lumsdain, 1995).

Lumsdain and Lumsdain (1995) describe creative problem solving as cyclic and iterative, with different mindsets needed at the different phases of the process. These phases and mindsets as described by Lumsdain and Lumsdain (1995) are problem definition (explorer), idea generation (artist), idea synthesis (engineer), idea evaluation (judge) and solution implementation (producer). Each mindset incorporates distinct thinking skills defined by the four-quadrant brain model of thinking modes or “ways of knowing” developed by Ned Herrmann. Figure 7a illustrates the mindsets described by Lumsdain and Lumsdain in related to Hermann’s four quadrant model. Figure 7b shows an alternative view of the creative problem solving framework.

Isaksen and Treffinger (2004) describe the evolution of the creative problem-solving framework:

[Version 5.0 of CPS] “began to frame and document a more descriptive, and less prescriptive, view of CPS. By descriptive, we mean an approach to process that provides a flexible framework in which problem solvers have many choices and make them on the basis of observation, experience, context, and deliberate analysis of the task (or metacognition). By contrast, by prescriptive, we mean an approach in which people learn and apply a predetermined or fixed set of steps or stages, for which there are specified approaches and outcomes. […] The current CPS framework [version 6.1] recognizes and incorporates the importance of metacognition and deliberate process planning and management in a descriptive framework. It emphasizes flexibility in selecting and using tools, stages, and components, and provides explicitly for personal styles, and context—deliberate efforts to personalize CPS” (Isaksen & Treffinger, 2004, p. 90)

The current framework for creative problem solving offers a suitably generic approach to problem solving using groups with different mindsets and backgrounds. In the degree structure shown in Figure 6, there are a number of core papers that are focused on problem solving and integrative thinking. However, it is the interrelationship between theory and practice and how these are placed within the degree structure that will determine the extent to which students will achieve the capabilities of trans-disciplinary problem solvers.

Figure 7. Creative problem solving
Adapted from Lumsdain and Lumsdain (1995)
It is suggested that the introductory problem solving module be targeted on the creative problem solving process, with students led through the phases of problem definition, idea generation, idea synthesis, idea evaluation and solution implementation in a general sense. Students can also be introduced to a number of specific approaches for deployment in these phases that are drawn from different disciplines. These may include approaches such as morphological analysis for idea generation and Pugh’s method of evaluation, both of which are derived from the engineering and design disciplines. The purpose of this introduction is to provide students with a toolkit of different methods that may be deployed in the conduct of their project work that at this stage is intended to be multidisciplinary in nature. The selection of projects is crucial to allow the students to reinforce their knowledge of problem solving approaches through practical application.

The second semester of study offers a module that focuses on integrative thinking, which by design is in itself integrated tightly to the multidisciplinary projects. The intention of this integration is to immerse the students in a pluridisciplinary project as a key stepping-stone to the second year of study. This involves a deliberate juxtaposition of different disciplines so as to enhance the relationships between them, for example taking an ideas generation technique utilised in an engineering discipline and deploy it in an artistic context. Such approaches have already been experimented upon with some degree of success (Connor, Karmokar, et al., 2015).

By the second year of study, students have started to develop some degree of disciplinary depth and are likely to be ready to consider crossdisciplinary work. In order to facilitate this, the second problem skills module focuses more formally on the nature of inquiry and how to work effectively in teams. The projects in the second year need to be designed to emphasise the development of suitable a suitable lens to investigate a topic from the stance of another area of study. In the context of the Faculty of Design & Creative Technologies this could involve for example a consideration of the aesthetics of engineering.

The final year of study involves a steep transition through interdisciplinary projects to the final transdisciplinary capstone project. For the first semester of study, the key to promoting interdisciplinarity is a consideration of presenting a suitable problem to be explored. Selection of this problem needs to draw on consideration of the disciplinary depth gained by the students and the types of projects previously undertaken. The final semester of study again sees a strong linkage between a core module on integrative thinking and the transdisciplinary capstone project. The integrative thinking at this stage of study is very much focused on the value level of disciplines discussed by Max-Neef (2005). The capstone project is likely to be based around contemporary “wicked problems”.

DISCUSSION

The nature of University education has remained largely unchanged for hundreds of years and as a result it is arguable that academia is in crisis. Whilst such claims are not new (Altbach, 1997) there is growing evidence that suggests a number of issues are converging that potentially will upset academic norms. Côté and Allahar (2007) outline a number of such issues including growing disengagement in the student body and increasing conflicts in terms of the role of academic staff. Such issues are well recognized and some authors go as far to suggest that we are experiencing the emergence of a “new normal” for academia and that Universities need to change to embrace this state (Tierney, 2014).

There is little evidence that Universities are changing and instead are perpetuating the status quo of disciplinary based thinking. The traditional paradigm of scientific discovery, dubbed ‘Mode 1’ by
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Gibbons et al. (1994), is the prevalent paradigm of knowledge production. Mode 1 knowledge production is characterised by the hegemony of theoretical or experimental science; by an internally-driven taxonomy of disciplines; and by the autonomy of scientists and their host institutions. In contrast, ‘Mode 2’ knowledge production is socially distributed, application-oriented, transdisciplinary, and subject to multiple accountabilities (Harloe & Perry, 2004; Nowotny, Scott, & Gibbons, 2003). Under the traditional paradigm of ‘Mode 1’ there are clear tensions between the roles of the university in servicing the needs of local economies and civil societies, those of the national state and the more abstract concerns of learning and the pursuit of knowledge (Delanty, 2001; Scott, 1990). Indeed, some authors go as far as to suggest that the normal state of affairs for much of the 20th century would be a significant degree of separation and segregation between the university, the state and the market (Harloe & Perry, 2004). Such separation is diminished by the emergence of ‘Mode 2’ production of knowledge, yet despite being proposed by Gibbons et al. (1994) over 20 years ago there is little progress towards ‘Mode 2’.

In its own way, academia is a complex “system of systems”, where emerging and shifting states and contexts dictate that any element of an academic crisis will have a range of possibilities for addressing the problem that may produce unforeseen impact in other elements of the crisis. This describes a condition that Rittel and Webber (Rittel & Webber, 1973) termed “wicked problems”, characterised as not having an exhaustively describable set of potential solutions or necessarily a well-described set of permissible operations that may be incorporated into their solution. This presents a major challenge for Universities, as addressing the perceived crisis through well understood mechanisms may result in further unforeseen negative outcomes. Anecdotal evidence suggests that attempts to implement a ‘Mode 2’ based approach may have fallen foul of small scale not being able to transcend financial boundaries imposed by Universities through their disciplinary structures.

This chapter presents a proposed new degree structures that arises like a phoenix from the ashes of one such failed attempt. The degree structure outlined in Figure 6 is in fact a minor incremental change from the existing Bachelor of Creative Technologies degree offered by Auckland University of Technology. However, the incremental change is accompanied by a significant change in mindset that will address the challenges imposed by institutional structures. Whilst success is never guaranteed, there is the potential to take a large, tangible step towards “Mode 2” knowledge production.

CONCLUSION

It has been suggested that transdisciplinarity is more than a new discipline or super-discipline, but instead a different manner of seeing the world that is more systemic and more holistic (Max-Neef, 2005). This chapter has outlined the outcomes of stepping back from current approaches to promote transdisciplinarity in undergraduate degrees and taking a more holistic view of how to promote transdisciplinarity. The chapter proposes a new degree structure that embeds problem solving skills as core to the production of “pi-shaped” people, defined as those that have disciplinary depth in two areas and the ability to work outside of their core area. In this regard, problem solving is considered an area where a student can achieve depth of knowledge. The degree is designed such that it produces an exchange of students across disciplinary boundaries and also structured so that it takes students on a journey through different models of disciplinary collaboration. The degree is seen as a key enabled of achieving so called “Mode 2” knowledge production. The success of this degree depends very much on partnership and collaboration across both discipline and organisational boundaries.
REFERENCES


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KEY TERMS AND DEFINITIONS

**Discipline:** The traditional view of an academic discipline is an area of study with its own theories, methods and content that is sufficiently distinct so as to be recognized institutionally in University structures.

**Ecotone:** A region of transition between two biological communities.

**Edge Effect:** Edge effects refer to the changes in population or community structures that occur at the boundary of two habitats.

**Interdisciplinarity:** Interdisciplinarity involves the combining of two or more academic disciplines into one activity. The distinction between interdisciplinarity and transdisciplinarity is subtle and explained in this chapter.

**Mode 2:** Mode 2 is a term from the sociology of science that refers to the way (scientific) of how knowledge is produced. It contrasts with Mode 1 production of knowledge. In Mode 2 multidisciplinary teams are brought together for short periods of time to work on specific problems in the real world for knowledge production.

**Transdisciplinarity:** Transdisciplinarity connotes a research strategy that crosses many disciplinary boundaries to create a holistic approach. It applies to research efforts focused on problems that cross the boundaries of two or more disciplines.

**Wicked Problem:** A wicked problem is a problem that is difficult or impossible to solve because of incomplete, contradictory, and changing requirements that are often difficult to recognize. The use of term “wicked” here has come to denote resistance to resolution, rather than evil.
Chapter 11

Enhancing Students’ Critical Thinking through Portfolios: Portfolio Content and Process of Use

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ABSTRACT

Portfolios can serve a crucial role in helping students develop their critical thinking in writing, thereby promoting write-to-learn philosophy in education. Still, not any portfolio’s content and approach can guarantee the achievement of this goal. Teachers’ concern in promoting students’ critical thinking needs to be reflected in their decision that is related to the evidences of students’ needs that helps to select their approaches of integrating and using them into class. Students’ reflection needs to underpin all stages of portfolio assessment through providing opportunities for their decision-making, initiation and creativity. Therefore, this chapter puts forward a student portfolio model along with its content and process of use. This learning tool was integrated within the course of Written Expression and used by 33 students at the Department of English at Abdelhamid Ibn Badis University during the academic year 2013-2014. Recommendations are also provided in order to make it a vehicle for critical thinking.

INTRODUCTION

Rapid changes in present, networked, knowledge society give rise to new challenges and requirements for work life competence. Productive participation in such society requires that individual professionals, their communities, and organizations continuously surpass themselves, develop new competencies, advance their knowledge and understanding as well as produce innovations and create new knowledge. To be able to productively participate in knowledge work, students must develop high-level cognitive skills such as problem solving and critical thinking, to learn to go beyond individual efforts, and collaborate for the advancement of knowledge.

To this end, assessment needs to be considered not only as a tool for measuring learners’ achievement, but also improving the quality of their learning. Within such culture, learners are active agents in the
assessment process who make judgments about their own work and that of others, monitor their progress and make decisions to improve. To create such learning opportunities self-assessment is regarded as an important tool for those committed to such goals as learner autonomy (Boud, 1995). Portfolios are among the self-assessment tools, which can have the potential benefit to make the link between learners’ engagement and success through promoting a reflective approach to learning where they take responsibility for what and how they learn.

Hence, enhancing students’ critical thinking via portfolios depends on the content and approach of implementing them within a given course. Indeed, such an objective is unlikely to be attained in case these tools are considered mere folders of collected work where students’ reflection and creativity are not involved. To this end, this chapter proposes a student portfolio that aims to develop student critical thinking in writing and thus autonomy in learning. In addition to explaining the content of that student portfolio, this chapter also aims to clarify the process of its use including its assessment. It needs to be noted that the provided illustrations and evidence concerning portfolio’s content and process were gathered by the author along with implementing this tool with her students within an EFL learning context. Yet, prior to engaging in such task, one needs to account for what constitutes critical thinking, its relation to creative problem solving and the role of portfolios in enhancing that process in learning.

CRITICAL THINKING: SOME DEFINITIONS

Living in an information-driven society, students need to construct their own meaning and apply what they have learned in new situations. To do so, they need to learn to think critically about knowledge and the world. Indeed, as Huitt (1998) claims in the information age, thinking plays a significant role in one’s success in life. Thus, meaningful education entails equipping learners with the tools that can help them think critically while providing them with multiple opportunities to make concrete such process through exercising their creativity, decision making, initiation, thereby involving actively in their learning process. Within this conception, academic success goes beyond achieving grades to developing reflective minds that can search for and evaluate information, solve problems, and learn through interacting and collaborating with others.

To help learners engage successfully in critical thinking, there is a need to understand what this process means. Critical thinking has its roots in critical theory and the concept of scepticism - the questioning of the source of truthfulness and the reliability of knowledge (Breech et al., 2000). Hence, reviewing the literature shows that despite widespread interest in promoting this goal “there is no consensus on a definition of critical thinking” (Fasko, 2003, p.08). Indeed, critical thinking has been defined from different perspectives. Definitions that draw upon philosophy often stress the metacognitive element of critical thinking, arguing that it can be defined as “thinking about your thinking while you are thinking to make your thinking better” (Paul, 1993, p. 91). In the same concern, Elder and Paul (1994) argue that critical thinking means that thinkers take charge of their own thinking. This also presupposes that people develop sound criteria and standards for analyzing and evaluating their own thinking processes and use of these criteria to improve the quality of their thinking (Uden & Beaumont, 2006).

By contrast, most theorists who base their theories, research and definitions of critical thinking on cognitive and developmental psychology often define critical thinking as “an active and systematic cognitive strategy to examine, evaluate, understand events, solve problems, and make decisions on the basis of sound reasoning and valid evidence” (Levy,1997, p. 236). Similarly, Diestler (2001) believes
that critical thinking is “the use of specific criteria to evaluate reasoning and make decisions” (p.2). It follows that, it is more purposeful and reasoned kind of thinking that intends to achieve a particular goal. This put into question the difference between critical thinking and ordinary thinking. In this respect, Lipman (1988) maintains that ordinary thinking is simple, straightforward and without standards while critical thinking involves “skillful, responsible thinking that facilitates good judgment because it relies upon criteria, is self-correcting, and is sensitive to context” (p.39). For this reason, critical thinking has been described as the scientific method applied by ordinary people to the ordinary world (Schaeferman, 1991). This is so, since it involves the skills of scientific investigation such as questioning, hypothesis testing, data gathering and analyzing, and concluding, etc.

However, critical thinking does not only involve mental processes, but also learning attitudes. Dewey (1933) argued that possession of knowledge was no guarantee for the ability to think well. Open-mindedness, wholeheartedness and responsibility were seen as important traits for developing the habit of thinking critically (cited in Walker, 2004). In a similar vein, Buskist and Irons (2008) maintain that to be critical thinkers students need to learn several subtasks including among others:

- Developing a skeptical approach to problem solving and decision making.
- Breaking down problems into their simplest outcomes.
- Searching for evidence that both supports and refutes a given conclusion.
- Maintaining a vigilant attitude toward their personal bias, assumptions, and values that may interfere with making an objective decision.

Furthermore, critical thinking is a process that includes both cognitive and affective domains of reasoning (Facione, 2006; Ennis, 1996). In this respect, Siegel (1988) claims that critical thinking involves “the willingness, desire, and disposition to base one’s actions and beliefs on reasons; that is to do reason assessment and be guided by the results of such assessment” (p.23). For Facione (2006), the personal dispositions or characteristics of open-mindedness, respect, tolerance and empathy are as important for critical thinking as the cognitive skills of intellectual curiosity, integrity and discipline. Accordingly, critical thinking is a combination of attributes and skills, which can be enhanced through an improved understanding of its centrality to ethically and intellectually rigorous practice, whether in medicine, nursing, social work, sports coaching or teaching history (Ennis 1996; Facione 2006). This implies that critical thinking has also a moral and ethical dimension. Thus, it has a value base that aims to improve human functioning, safety, health and emotional well-being (Gambrill 2005; Mason, 2007).

It can be concluded, that critical thinking is a process that encompasses skills, attitudes as well as affective and ethical issues. Therefore, promoting this process requires raising students’ awareness of its importance, processes that they are engaged in and the targeted objectives, besides teaching them critical thinking skills and active learning strategies that can help them engage successfully in the process and develop more critical attitudes. This is through involving them in effective questioning, reflection, self-assessment and thought provoking tasks that stimulate their curiosity and inquiry. Still, to make students actively participate in the critical thinking process it is important to create a friendly, supportive and non-threatening classroom atmosphere that promotes risk-taking and speculative thinking. Within such atmosphere, students’ voices are heard and considered, respect is shared and dialogue is maintained. To help achieve that potential, different tools have been suggested among which students’ portfolios are advocated.
CRITICAL THINKING AND CREATIVE PROBLEM SOLVING SKILLS

Today’s citizens must be active critical thinkers who are able to construct knowledge and make relevant decisions to improve their living. Critical thinking has become a valuable skill within an ever-changing global economy. Indeed, findings have revealed, “the skills employers consider to be most important in graduates are creativity and flair, enthusiasm and the capacity for independent and critical thinking” (DETYA, cited in Johnstone, 2006, p.246). In the same concern, since the world is facing different problems and crises, which are increasingly emerging (e.g., global warming, pandemic diseases, and economic crisis, etc.), creative problems solving abilities are also required to find solutions to these challenges.

According to educator Hoerr (2003), the notion of intelligence has been changed. We no longer rely on the limits of our single mind to access the information resources we need to solve problems. This means that educational goals need to go beyond emphasizing students’ access to information towards promoting its process creatively for a variety of purposes. For this reason, Conley (2008) maintains that analysis, interpretation, precision and accuracy, problem solving, and reasoning can be as or more important than content knowledge in defining what success in college courses means. Therefore, today’s mission of 21st century education is to teach students critical thinking and creative problem solving skills effectively in the classroom. So, how are these connected?

In fact, critical thinking relates to other skills. As Richard and Elder (2006) argue engaging in high-quality thinking, involves functioning both critically and creatively since one produces and assesses, generates and judges the products of his or her thought. Thus, critical thinking is connected to creative thinking skills. Besides, according to P21 critical thinking entails using reasoning effectively, using systems thinking, making judgments and decisions and solving problems. The latter includes solving different kinds of problems, asking and identifying questions, which can help achieve this task. This implies that to think critically one needs to possess as well problem-solving skills.

In addition, as defined previously critical thinking involves problem solving skills since its objective can cover solving problems. Yet, findings solutions requires as well thinking critically. According to Krulik and Rudnick (1987) problem solving refers to “the means by which an individual uses previously acquired knowledge, skills, and understanding to satisfy the demands of an unfamiliar situation. The student must synthesize what he or she has learned, and applied it to a new and different situation (p. 4). This means that to solve a problem, students need to apply existing knowledge and think about what strategies to use and how to implement them more effectively. This can enhance their creativity since by solving problems they experiment and discover new things by themselves.

Thus, critical thinking and creative problem solving skills are interrelated. To promote these skills, engaging learners in active learning was advocated. For instance, Acker (2003) emphasizes the role of active and participatory learning on developing students’ critical and problem solving skills stating that: “The most accomplished teachers succeed in engaging their students actively in the learning process, involving them in participatory exercises and discussions as problem solvers rather than treating them as ‘empty vessels’ to be filled with knowledge” (p.04). Similarly, Ziegler (2001) contends that active learning is an appropriate response to the problem faced by adult education that “works in a world that is constantly changing, where there are more question than answers, and where barriers and frustration continually impact their work” (p.03). To promote active learning, different learning and assessment approaches have been suggested among them students’ portfolios.
PORTFOLIO ASSESSMENT AND STUDENTS CRITICAL THINKING

To respond to the increasing demands of a knowledge based-society, developing an independent, self-directed, life-long learner has become a focal concern of higher education. Assessment purpose is no more limited to grading or indicating passing/failing, but rather it goes beyond this to support students' learning. Indeed, students need to be involved in the classroom assessment process to get motivated, learn how to think about their learning and how to self-assess thereby learning how to learn and getting more self-directed (Davies & Le Mahieu, 2003).

In this respect, students’ portfolios have been used as a powerful instrument for formative assessment or for assessment for learning and advocated by many researchers (see for example; Birgin, 2003; De Fina, 1992; Micklo, 1997). According to Archbald and Newmann (1992), “a portfolio is a file or folder containing a variety of information that documents a student’s experiences and accomplishments” (p.169). Yet, portfolios are not mere collection of students’ work, i.e. product. Rather, they are considered as a means through which learners can reveal their learning process and attitudes and communicate their views. This is through demonstrating how their work has been collected, what are their current learning needs, strengths and weaknesses as well. Besides, portfolios are not just organized documentation that demonstrates learning achievement over time, but they are rather reflective tools that clarify learning beliefs, attitudes, evidence and criteria as Jones and Shelton (2011) state:

Portfolios are rich, contextual, highly personalized documentaries of one’s learning journey. They contain purposefully organized documentation that clearly demonstrates specific knowledge, skills, dispositions and accomplishments achieved over time. Portfolios represent connections made between actions and beliefs, thinking and doing, and evidence and criteria. They are a medium for reflection through which the builder constructs meaning, makes the learning process transparent and learning visible, crystallizes insights, and anticipates future direction (Jones & Shelton, 2011, pp.21-22).

It is thus, a process that involves purposeful selection and analysis of evidence for the sake of improvement and assessment of students’ learning. To this end, students’ reflection and critical thinking are required to achieve that aim. As a self-assessment tool, learners use portfolios to monitor their progress and make judgments about their own learning process as Julius’s (2000) research has shown. Thus, portfolios can contribute to their ability to reflect upon their work, i.e., develop meta-cognitive skills. Indeed, Jones and Shelton (2011) claim that portfolio development “provides not only a means for internalizing learning at deeper level, but also a means for developing and/or refining higher order thinking skills”(p.25). This is so since, portfolios construction involves skills such as awareness of audience, awareness of personal learning needs, understanding of criteria of quality, the way in which quality is revealed and the development of the skills necessary for the task completion (Yancey & Weiser, 1997).

Spalding (1995) furthermore asserts that “portfolios encourage students to think creatively, critically, and logically… to set goals for their own literacy learning…and to demonstrate their ability to use reading, writing, listening, and speaking in an integrated way and for authentic purposes” (p. 2). Thus, a portfolio is not just a product reflecting students’ work, but it is a process involving “student’s self-reflective, meta-cognitive appraisal of what was learned, how it was learned, when it was learned best, and, more importantly, why this learning is valuable” (Zubizarreta, 2008,p.02). In doing so, it can be a powerful tool for students’ self-assessment, thereby helping them critically analyze their own products and processes, and as a consequence to become more aware of their own weaknesses and strengths.
Enhancing Students’ Critical Thinking through Portfolios

(Sluijsmans et al., 1999). In this respect, research has shown that students’ engagement in such a process “provides an effective means of developing their critical self-awareness” (Nunan, 1988, p.116) which can help them take actions to learn better and improve.

Hence, to get portfolio’s potential not any reflection would serve the aim. Students need to reflect regularly (it needs to be organized) and systematically (following a given format) on their learning process and outcome to track their learning progress over time. Besides, their thinking needs be critically involving conceptualizing, applying, analyzing, synthesizing, and/or evaluating information gathered from their reflection observation and reasoning (Scriven & Paul, 1996). As Zubizarreta (2008) stresses: “The intrinsic merit of learning portfolios is that they involve students in the power of reflection, the critically challenging act of thinking about their learning, and constructing (and communicating) a sense of the learning experience as a coherent, unified, developmental process” (p.02). Thus, students’ reflection and critical thinking through their portfolios can contribute to raising their awareness of their strengths and weaknesses, as well as guide them towards setting effective goals and plans, making decisions and monitoring their progress.

In fact, Brown’s (2001) research has shown that this reflection through language portfolios allows learners to realize their learning abilities and discover their personal empowerment. It is, thus, a self-discovery which is likely to enhance their self-confidence as one of Brown’s (1999) interviewee has reported: “It was a discovery of myself that gave me satisfaction that I have accomplished so many things and I have acquired so much knowledge” (p.104, cited in Brown, 2001, p.05). Accordingly, reflection is likely to bring about a change in learners’ perspectives and behaviors (Usher, 1985).

In addition to portfolio’s potential in developing students’ reflection and critical thinking skills, using this assessment and learning tool can give teachers a broad sense of the skills learned during the critical thinking process (Ennis, 1993). This is so, since it informs teachers of what students learn, how they learn, i.e., how they analyze information, use strategies, set learning goals and plans, make decisions and realize their achievement. So, using this tool can mirror students’ critical thinking skills, thus enabling teachers to focus on areas where guidance is needed.

Besides, the process of learning by reflecting and thinking critically through implementing portfolios may have a long life standing to include learners’ professional life and thus help them unveil their professional weaknesses and strengths. “A degree with a portfolio makes you assess your professional life; without a portfolio you just know your academic strengths, but you do not know your professional [abilities] and strengths” (Brown, 1999, p.103, cited in Brown, 2001, p.05). Using portfolios in language learning can, then, result in meaningful learning that is related to students’ professional life.

We have heard so often from students over the years that they have felt that their college classes were irrelevant and had no connection to ‘real-life’…. On the contrary, students who have experienced the portfolio process report a high degree of connectedness between what they do in in the college classroom with what they experience beyond the classroom door. The real-world nature of portfolio work bridges the theory-to-practice gap in ways that result in meaningful learning and change…. It comes to be owned by the learner, and therefore it becomes part of the fabric of one’s professional life and development (Jones & Shelton, 2011, p.23).

Hence, though the use of portfolios can help enhance students’ critical thinking as stated above, this does not mean that it will lead automatically to such effect. Rather, their contents, purpose and the way they are approached determine the achievement of such potential. To this end, to make effective use of
these devices this chapter suggests a student portfolio model and provides illustrations, guidelines and recommendations on how to integrate them into classes and train students into their use. As stated previously, the provided implications and recommendations are based on one’s experience of implementing that portfolio model at the department of English (Abdelhamid Ibn Badis University) within the Written Expression course that aims to enhance students’ writing skills in English.

Portfolio Purpose and Expected Audience

Before deciding the contents and process for the portfolio, there is a need to account first for its purpose and intended audience. This is because “The purposes and the audience for a portfolio are crucial in determining what is selected to go into it and how the contents of the portfolio are arranged” (Richards & Farrell, 2005, p.103). Therefore, before defining and clarifying for students what evidence to select to demonstrate their competence it is necessary to think about the purpose of the portfolio and how it fits the objective of the course. Indeed, in designing the suggested student portfolio, the following parameters were taken into account:

1. The course objective in which the portfolio training process was integrated (the Written Expression module).
2. The participants’ language proficiency level and learning needs.
3. The participants’ access to the learning resources required for the development of their portfolios (books, internet resources, etc.).
4. The time allocated for teaching the course.

With regard to its purpose, the language portfolio suggested here is a learning portfolio that intends to develop students’ critical thinking in writing and thus autonomy in learning. This is through involving them in making and taking decisions over their learning process, assess this process and reflect continuously over their progress as well as their learning needs and goals. It covers both functions: reporting (a form of alternative assessment) and pedagogical functions (a reflective tool to foster student autonomy and learning to learn in foreign language education). It is, thus, learning as well as a reflective tool. The developed students’ portfolios were assessed by the teacher/author who was the main audience. Other students, teachers within the same university and their parents could also view portfolios. It needs to be noted that though the suggested portfolio is a language portfolio, it can be implemented in other disciplines.

Portfolio Content

Decision needs to be made regarding the kinds of evidence that will best show student progress toward the identified learning goals. The physical size of the portfolio is to be limited. Besides, teachers need to take into account the time devoted to its understanding and development, in addition to how to train students into its use. It is also necessary to have clear and explicit criteria for both teachers and students to guide assessment. With regard to the suggested portfolio, this contains two sections: ‘My Evidence’ and ‘Reflection on My Evidence’. Yet, it is worth noting that the portfolio’s content needs to be updated continuously according to the students’ changing learning needs and interests which can be gathered via their portfolios, the use of observations checklists, interviews and questionnaires.
My Evidence

This section contains the student’s selected artifacts which depicts their achieved work or involvement in the learning process. It aims to provide them with the space to make their voices heard within the teaching learning process. This is by encouraging them to suggest teaching ideas, lessons, exercises, etc. to their teacher and peers. (There are other parts included here, like suggesting proverbs, jokes, etc.). This is likely to help them understand and practice the lesson. In making such selection, students are provided with opportunities to reflect, make choices and decide upon the evidence which match the portfolio’s objective and the criteria of selection. Figure 1 illustrates the content of this section.

1. The Homework: Students can include all those assigned homework and projects in class in their portfolios. This is in order to encourage them revise each lesson regularly, practice its exercises and gain more feedback about their performance to improve and prepare better for their exams. Also, to make them more organized students who are aware of the notion of time and its value in their learning process the teacher can ask them to write the week, the date and time of their accomplishment of their homework. S/he can also provide them with the tasks’ objective, in order to help them understand what is expected from them in terms of answers. This is also meant to familiarize them with the way objective’s statements should be drafted since they were required to

Figure 1. The contents of students’ selected evidence
do so for their suggested exercises, lessons and tests within this section. To guide them, homework worksheet can be provided as Figure 2 shows.

2. **Suggested Exercises**: Students are required here to suggest their own exercises for each lesson taught in class that have been selected and done by them. The number of these exercises can be limited by the teacher that depends on the course’s objective. These can be taken from books or Internet resources. Still, there is a need for providing them with a sample to follow during the first semester, in order to make clear the criteria of selection and presentation (see Figure 3). These are as follows:

a. The exercises suggested should be related to the lesson.
b. The lesson’s title needs to be stated from the outset.
c. The exercises’ sources must be stated after the lesson’s title.
d. The reason for inclusion or selection must be explicitly justified.
e. The students’ answers must be clear. In case there are key answers, these must be provided after answering while pointing to the mistakes, correcting and evaluating their performance.

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**Figure 2. Students’ selected evidence sample format of the homework**

The Student’s Name:

Week:    Date:    Time:

<table>
<thead>
<tr>
<th>Homework Nº11: Sentence Classifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>The tasks’ Objectives: To make the difference between declarative, imperative and interrogative sentences, and between simple, compound, complex and compound-complex sentences.</td>
</tr>
</tbody>
</table>

**Exercise Nº1, Nº2...**

**Student’s performance:**

**Teacher’s remark:**
3. **Suggested Lessons**: Student should suggest lessons for their teacher and classmates. The criteria for their selection are put within the present context as follows:
   a. Two lessons should be suggested during each semester.
   b. The lessons should not be part of the syllabus, but they should have the objective of improving students’ writing in English.
   c. The title of each suggested lesson, its source and reason for inclusion should be stated clearly.

4. **Suggested Tests**: At the end of each semester, students should suggest a test of the course for the rest of his/her class following these criteria:
   a. The test should cover the lessons taught during the semester.
   b. The lessons this test covers, its source and objective of inclusion ought to be clear from the outset.
   c. The grading scale needs to be included.
   d. The key answers should be clear.

and what is needed for its improvement. The teacher needs to see the actual performance (with their mistakes).

Figure 3. Students’ selected evidence sample format of the suggested exercises

Exercise N°1 ; N°2 ............
Correcting my mistakes:
My performance was (very good, good, ok, poor, very poor), because .............
I need to ........
5. **My Teacher’s Tests:** Students can put all the tests they took in the course within this section of the portfolio. This includes as well their correction, the obtained mark and the teacher’s remark for their performance. The objective of including these tests in the students’ portfolios is for the purpose of helping them save those corrected tests and go back to them whenever they revised their lessons, besides reflecting on their performance, thereby prompting them to learn from their mistakes and improve.

6. **Other Suggested Worksheets:** To enhance students’ creativity, they can also add other materials to their portfolios such as proverbs, poems, jokes, riddles, stories in English, etc. Besides, they had the choice to design the portfolio’s cover, draw or add pictures in relation to the portfolio content. They can design ‘My Personal Dictionary’ worksheets which aims to enrich their vocabulary through writing the new words, phrases and expressions which they have learned, then stating whether they were using them in speaking or/ and writing.

**Reflection on My Evidence**

With regard to ‘Reflection on My Evidence’ section, this contains students’ reflection over what has been studied and practiced inside and outside the classroom. It also covers their learning needs, goals, plans and revision schedule. Reflection over their progress and estimation of their feelings in learning are also intended through this section. Also, students have a space to reflect over their classmate’s performance, state their comments and put forward recommendations. In doing so this section aims to:

- Involve students in assessing their process of learning, so that they become more aware of the progress they are making.
- Encourage them to reflect on their learning process and outcome, thus encouraging them to make the necessary plan to achieve their learning objectives.
- Reflect over other’s performances, interact and speak up their ideas.
- Encourage them to write and express their ideas and thoughts in English.
- Help their teacher get an idea about their learning process (including their needs and preferences) and progress in the course.

As Figure 4 shows this section consists of the following parts:

1. **Reflection on the Lessons:** Students are asked to reflect over the lessons. This is by summarizing what they have learned, describing how they find its content while backing up their answers with justification. Classwork or exercises done in class are to be reflected over within this part. They should describe how they found them and the reason why they have attributed such quality to them. Hence, their learning needs may not be met in spite of the teacher’s explanation and the exercises practiced in class since confusion and misunderstanding can emerge. Therefore, after completing both reflections, students should express such needs in relation to that lesson. They are also expected to reflect over what should be done and how to meet these needs and achieve their learning goals. This is through making a plan, i.e., following a particular schedule for revision.

2. **Reflection on the Homework:** This process entails describing each assigned-homework and the strategies used while completing its tasks. It is important that the teacher maintains the need to do so immediately after finishing the homework, so that students could remember the strategies
implemented to provide their answers. After receiving the teacher’s feedback and attending the correction of the homework in class, the student can reflect on his/her performance stating whether it was very good, good, ok, poor or very poor, while justifying why s/he performed in such a way. (See the appendix)

3. **Reflection on the Tests and Exams**: Within this part, students are asked to fill in reflection worksheets concerning their performance of the tests and exams of the course which were suggested by their teacher during each semester. This worksheet shares the same content with that of reflection over the homework. i.e., it requires students to describe the exam or test which they have already taken, justify their description, then describe their performance and explain the reason why they did so. Yet, within this part they should also state their needs in order to improve such performance.

4. **Reflection on My Progress**: By the end of each semester, the teacher can hand a progress checklist which contains can-do statements which are related to the course and the portfolio’s objectives. Students use this checklist to record what they think they can do on their own, the things which they feel they cannot do yet (these are their objectives) and those they can do with their teacher’s help (or with someone’s help).

5. **The Development Checklist**: To help students keep track of the completion of the required components, a development checklist can be designed for them to achieve this purpose. This checklist consists of a set of items where they can check what has been done or what remains to be done within this process. Yet, they needed to set a timeline for their portfolio development process so that they could review the final work by a given time.
6. **My Questions to my Teacher:** Students could ask questions to their teacher in relation to the lessons taught, the course content or the portfolios. Questions could be addressed as well about how to improve their English, more particularly their writing skill.

Finally, after assessing student’s portfolio the teacher can indicate his/her remarks and recommendations in the last part of the portfolio, called ‘Teacher’s Remarks and Recommendations’. Indeed, to assess students’ portfolios, a scoring rubric can be used. This needs to be handed to students from the beginning of the year while introducing the portfolio’s content. More details about the portfolio scoring rubric, their criteria of assessment and the way assessment are explained in the following section.

**Portfolio Process**

To make effective use of their portfolios within a given course, students need to be trained into their use. This training implies providing them with both knowledge about the process of developing their portfolios including awareness raising (e.g., explaining the objective of each section and its content) and the related practical skills (e.g., what strategies to select to complete regularly their portfolios, how to select artifacts that meet the intended criteria, how to organize the different sections and parts, etc.). To achieve its objective, the present training process was based upon the following principles.

- **Motivating the Students:** The teacher’s concern is to raise the students’ interest in developing their reflection and motivation in using their portfolios. This is in order to help them identify with the process, consider its value to their learning and develop a sense of commitment and ownership towards its achievement, thus making from them lifelong learners who can use such tools on their own to learn and develop more professional skills in their future career. This is through
  - Raising their awareness of the importance of being reflective learners and the need to develop their portfolios to achieve this purpose.
  - Providing them with the choice to take some decisions concerning the portfolio content and process of use.
  - Relating the portfolio to the course’s content while taking into account their learning needs and styles in its design and use so that they can see its relevance to their learning.
  - Raising their self-confidence and self-esteem through providing them with opportunities to voice their opinions, listening to them and showing interest in their ideas, suggestions and taking them into consideration.
  - Checking regularly their portfolios and showing interest in them.
  - Creating competition among the students informing them that the best student portfolio will be rewarded with extra points, in addition to reminding them of the portfolio’s mark which can help them succeed.

- **Involving Them in Learning:** Students’ involvement in learning is not likely to be achieved unless they understand what is required in such a new context. To this end, raising their awareness of how their portfolios need to be developed and used in the course has been considered the basis for this training. The latter has to involve providing them with the necessary guidelines, feedback and support regarding this process such as how to select relevant artifacts, how to plan, identify their needs, reflect, organize the three sections, etc. After this awareness raising step, students should be encouraged to make choices not only concerning what to include and how in their portfolios, but
also what and how to learn in the course. In addition, they should be invited to initiate new ideas and tasks for their portfolios during the second semester.

- **Enhancing Their Reflection:** Much Emphasis has to be put on the need to keep from students’ reflection an ongoing process that mirrors their learning needs and wants. This is by clarifying first what reflection means, how it needs to be achieved and why it constitutes the main element of their portfolios, then encouraging them to engage in such process both inside the classroom through asking them to reflect on the lessons which they attended. Outside this context, reflection can also be promoted by inviting them to reflect on the practiced exercises in class, homework, exams, tests, learning progress and projects.

- **Promoting Their Interaction:** Promoting students’ interaction is also intended in this training since student autonomy is not just an individual but also a social construct growing out of interaction with others. Therefore, peer-assessment and collaborative learning tasks can be integrated where the student acts as a teacher and researcher who involve in sharing information, negotiating meaning and taking decisions. Playing the role of the teacher, the students can also be invited to step on the board to explain lessons to their classmates who evaluated in turn their explanation and provided feedback to their questions.

The process of training these students into portfolio development involves a set of stages which are:

1. Raising their awareness of the importance of being autonomous and reflective on their learning.
2. Introducing the portfolio content and process.
3. Checking how they are proceeding with their use and providing continuous feedback.
4. Assessing their portfolios.
5. Evaluating students’ portfolios.

### Raising their Awareness

Prior to introducing the portfolio content to students, there is need to raise their awareness of the importance of being autonomous learners and the need to reflect on their learning (both its process and outcome) and take the initiative to improve. They need to conceive the value of using their portfolios to enhance such reflection. Yet, students might not understand what reflection entails. Besides, reflection needs to be structured to enable students improve the process (Bringle & Hatcher, 1996). Therefore, to explain for the students this process and make clear its objective and components one put forward a model of reflection upon which the suggested portfolio is based. Reflection here involves thinking about one’s learning through involving in self-questioning, planning and acting as Figure 5 displays.

Accordingly, reflection includes an inner dialogue with the self where the learner questions the teaching contents in relation to a particular course, i.e., the lessons, exercises and homework. This is through addressing questions such as: How do I find the lesson, exercises and homework? What do I need to understand it better? Which exercises do I need to practice more? How to revise regularly for my lessons? Moreover, since assessment relates to teaching and learning self-questioning needs to concern as well the assessment contents including description of the teacher’s exams and tests, thereby indicating their needs and concern within a given course. Still, to identify their learning needs, students need to be aware of the importance of reflecting on their performance of exercises, homework, exams and tests as well as their strategies used in completing them so that they can decide which strategies work better.
Also, their learning progress can be part of this self-questioning process through determining how much progress they are making, in which language area and what kind of improvement is required.

Furthermore, reflection is not just a matter of questioning the learning process and outcome but it is also concerned with planning and taking actions for its achievement. The former involves making decisions regarding this process in attempt to solve problems associated with it, thus improving its quality. This requires first identification of their learning needs and goals then setting plans to achieve them. To this end, teachers need to stress the importance of being organized (doing their learning tasks regularly and completing them with respect to time) and the importance of planning for their learning to attain such an aim.

Hence, decision-making remains an idle process without actual practice in its intended context. Thus, it is necessary to encourage students to act and take the initiative to put into practice their decisions and plans. This is through selecting and suggesting artifacts to include in their portfolios, writing down regularly their reflection on them, assessing their performance and providing feedback on other’s work, collaborating with their peers and assessing this experience. In the same concern, to help them overcome some of their fear and anxiety of talking in front of their teacher and peers, the students can be provided with the chance to present whatever work they prefer to share in class in relation to the course, i.e., a lesson, a story, etc.

Figure 5. A model representing students’ process of reflection on learning
Introducing the Portfolio Content and Process

Teaching aids such as videos and PowerPoint presentation can be used to explain the portfolio’s content and process besides providing students with sample portfolios. Guidelines regarding the format of the portfolio and evidence to be selected can also be provided. For instance, within the present context one tried to clarify more what should be done and how to make the right selection of artifacts, organize and present them well, maintaining meanwhile the need to suggest a variety of exercises for each lesson, a relevant lesson that can help improve their writing skill and a test that covers all the lessons taught during the semester while clarifying the source(s) and the reason for their selection. Besides, to reflect properly on such artifacts one’s concern was devoted to making clear the criteria for reflection that are:

- Reflections need to be kept up to date (regularly done), stating the week, time and date of their writing.
- They need to be expressed clearly. Thus, the student’s use of his/her dictionary is recommended.
- Honest description of the teaching and assessment contents is required. This is through summarizing the main points covered by each lesson, how they found its exercises and homework, in addition to their description of the tests and exams they took and assessment of their performance and indication of their progress after each study semester stating what they could do on their own, with help or what was not yet achieved.
- Each description of lesson, homework, test or exam needs to be justified clearly.
- The students’ needs should be clear, indicating thus where the gap lies in relation to the lessons taught or exercises practiced in class. Those needs are likely to get more transparent after taking a test/ and an exam.
- To achieve their needs, the students are required to set a plan to achieve them, indicating what should be done and how along with their schedule for revision of the Written Expression course.

Checking How the Subjects are Proceeding with Their Use and Providing Continuous Feedback

To provide continuous feedback to students, there is need for scheduled conferences where dialogues can be maintained along their use of portfolios. In addition to these conferences, teachers can devote the first thirty minutes of each lesson to checking the students’ portfolios by asking them questions such as: How are you doing with your portfolios? Are there any questions, problems or difficulties encountered with their development? They can go along the rows to see their portfolios and listen to their inquiries. Along this stage, there is a need to maintain the importance of keeping the portfolio up-to-date by completing its parts regularly, mentioning the date, time and week of doing so, besides organizing each section, and making clear each part of it and including pieces that meet the criteria of inclusion and reflecting on them.

Furthermore, to think critically via their portfolios students should develop a liking for them to devote their commitment and concern to their accomplishment. Therefore, teachers need to remind them of their benefits over their learning which could not be attained unless they like this process. Indeed, it is crucial to motivate and encourage them to engage more in writing portfolios. One attempted, for instance, to achieve this objective through praising them for their creativity, use of a particular strategy or good selection of artifacts, besides pointing out to the mark that they would have for their assessment.
Assessing Their Portfolios

As stated before, to assess the students’ portfolios a scoring rubric can be implemented. Rubrics “present a continuum of scoring criteria with descriptions that identify the levels of quality” (Jones & Shelton, 2011, p.138). Indeed, a scoring rubric is opted for when the aim is to assess the quality of the produced students’ portfolios. Moreover, providing students with these assessment criteria and clarifying them from the outset is likely to guide them while developing their portfolios. Using rubrics can also “provide the assessor with a tool that helps ensure a greater measure of consistency and standardization across multiple portfolios” (Jones & Shelton, 2011, p.138)

The present scoring rubric is organized using three levels: Excellent, satisfactory and unsatisfactory. Excellent indicates effective selection, communication of and reflection over the evidence, besides thoroughness, high level of organization and appropriate use of the language. Satisfactory reflects a level of accomplishment beyond the basics, indicating accomplishment of most of the requirements. Unsatisfactory illustrates poor selection of artifacts with inadequate or no justification of inclusion, missing or unclear honest reflections, lack of organization and frequently occurring errors in the language.

The criteria upon which the portfolio is being assessed range from content to organization and presentation criteria. These include:

- **Artifacts Selection**: Their support to the portfolio purpose, their organization, variety, clarity and relevance, i.e., they can help students learn, understand the lessons and improve their English.
- **Reflections**: Their clarity, honesty and completion of the assessment of the teaching contents and learning process and progress.
- **The Portfolio**: Completion of all sections respecting timelines, their organization and creativity.
- **Language Form**: The use of grammar, spelling, punctuation and capitalization rules.

These assessment criteria are to be provided and explained along with the introduction of the portfolio content. To facilitate the process of portfolio construction, samples of previous students’ portfolios can be shown for students. The assessment process takes place at the end of each semester after collecting the students' portfolios. Yet, students need to be informed about the deadline of their submission so that they can allot time to revise them following the teacher’s guidelines and feedback. Within the present context, this feedback was provided during each last conference preceding their submission where their portfolios were checked.

After considering the content of the students’ portfolios, following the criteria’s weight, a total score is attributed to each and a set of remarks and recommendations are provided on the basis of the achieved work. These remarks aim at raising students’ awareness of what was missing in their portfolios in terms of content and mode of use, thereby clarifying why they received such grades. Whereas, recommendations have been addressed what should be done and how to produce and implement effectively their language portfolios within the present course. Evaluation of these portfolios needs also to be part of this process, so that revision and improvement might be brought to meet the intended outcome.

Evaluating Students’ Portfolios

Evaluation within education concerns “the collection, analysis and interpretation about any aspects of a programme of education and training as part of a recognized process of judging its effectiveness”
It is thus an attempt to gain insight into what is going on in order to judge its worth and make decisions for refinement. To help enhance students’ critical thinking, the process of evaluating their portfolios needs to include both product and process evaluation. Evaluating the product, i.e., the student portfolio seeks to find out which section(s) of the portfolio most of them did not accomplish and those that were completed successfully. This is to reveal to what extent their portfolios meet the pre-set criteria for their development. Evaluating the process aims to unveil how students proceed with developing these learning tools. Evaluation (of both process and product) can be achieved through administering a questionnaire to students to fill in. This data collection tool can also be used to get an idea about their views and feelings concerning this process, including the teacher’s explanation and guidance within.

**FURTHER RECOMMENDATIONS**

To enhance students critical thinking via portfolio assessment, teachers need to believe in constructivism where “students must themselves be active agents in their own learning, transforming what is to be learned through the screen of their own experience and existing understanding to be successful learners must construct and reconstruct, for themselves, what is to be learned” (Hillocks, 1999, p.93). Indeed, this assessment tool is unlikely to contribute to such goal in case cultural transmission approach to learning is still dominating the language classroom. As Farmer and Eastcott (1995) state: “Some tutors reported that, if assignments are not carefully designed, students can be just as instrumental in their approach to the preparation of portfolios as they are to any other learning task”(p.92). Thus, the way teachers approach portfolio assessment needs to reflect their interest in and commitment to enhancing such a learning model. To this end:

- Teachers need “to learn to stand back, and to hand over the responsibility of the learning to the students to trust that the students will learn, and that the reflection writing and discussions are part of the students’ motivation” (Bryant & Timmins, 2002, p.25).
- Portfolios should be considered “a critical account of the contents-more than an annotated contents list-which provides an opportunity for the student to contextualize the work and demonstrate the learning achieved” (Brown & Knight, 1994, p.83).
- It is also required that students recognize the importance of reflection in constructing their portfolios and receive the necessary guidelines on how this process can be achieved.
- Students’ differing needs, learning styles, beliefs and opinions are to be embraced
- Students need to understand that quality not quantity counts within portfolio development. For this reason, teachers can provide interim assessment opportunities, telling them whether the evidence they are assembling is appropriate or not (Race et al., 2005).
- Time should be devoted to discussion, collaboration, peer-feedback on the achieved work where students can voice their ideas and reflect on their practices, besides giving them opportunities for their creativity and involvement.
- Feedback within portfolio assessment is supposed to be descriptive rather than just involving marks. For this reason, teachers need to structure their feedback through using an assessment pro forma so that their comments and notes are directed to students (Race et al., 2005).
• Teachers need to work as a team to plan for the implementation of the portfolio assessment, discuss issues related to its process and take decisions to improve it.

CONCLUSION

Portfolios are not just alternatives forms for assessing students’ performance over time, but they can also be a powerful tool to enhance their critical thinking within a given course. To achieve this goal, teachers need to consider first the portfolio’s purpose so that “learning outcomes can be linked to the institutional (and national) curriculum goals” (Gottlieb, 1995; cited in Kohonen, 1999, p.289). Besides, its content or selected evidence needs to stimulate students’ reflection, critical questioning and decision-making. This is through providing them with a variety of opportunities to negotiate that content, make selection based on the provided criteria, and justify each included - evidence. Also, the portfolio’s process of use needs to serve that goal. Indeed, there is a need to train students into using their portfolios so that they get more familiar with the ‘what and how’ of that process. In addition, it is important to make from their reflection an ongoing process to reflect their learning needs and progress. This is through encouraging them to fill in reflective worksheets and interact with their teacher and peers. In the same concern, opportunities should be provided for students via conferences to communicate their selected evidence, their views, learning needs and concerns along the use of their portfolios. Finally, to enhance students’ critical thinking via portfolios teachers needs to bear in mind that their motivation and willingness to engage in completing them remain the key element to achieve that aim.

REFERENCES


**ADDITIONAL READING**


Enhancing Students' Critical Thinking through Portfolios


**KEY TERMS AND DEFINITIONS**

**Assessment**: The process of collecting information about student learning. Throughout the learning process, assessment is used to inform teaching and student learning. As a result of assessment, teachers can adjust their teaching. Students also benefit from assessment. They need to receive a considerable amount of descriptive feedback to enable them to continue or adjust what they are doing to be effective learners.

**Criteria**: Indicators of successful performance by which an assessment task will be judged.

**Evaluation**: The process of reviewing collected evidence and making a judgment about whether students have learned what they need to learn and how well they have learned it. Evaluation is used to tell students how well they have performed as compared to a set of standards. Typically, evaluative feedback is encoded: that is, it is reported using numbers, letters, checkmarks, and so on.

**Feedback**: Information that results from formal or informal assessment and that is used by teachers and students to enhance teaching and learning.

**Knowledge-Based Society**: A knowledge-based society refers to the type of society that is needed to compete and succeed in the changing economic and political dynamics of the modern world. It refers to societies that are well educated, and who therefore rely on the knowledge of their citizens to drive the innovation, entrepreneurship and dynamism of that society’s economy.

**Portfolio**: Is a compilation of student work assembled for the purpose of (1) evaluating coursework quality and academic achievement, (2) creating a lasting archive of academic work products, and (3) determining whether students have met academic requirements for courses, grade-level promotion, and graduation.
**Reflective Practice:** Is the capacity to reflect on action so as to engage in a process of continuous learning. A critical attention to the practical values and theories which inform everyday actions, by examining practice reflectively and reflexively.

**Self-Assessment:** The involvement of learners in making judgements about their own learning.
### APPENDIX

**Table 1. My reflection on the homework**

<table>
<thead>
<tr>
<th>Date:</th>
<th>Time:</th>
<th>Description of The Homework</th>
<th>How Did You Find This Homework (X)</th>
<th>Why Did You Find It So?</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Difficult: it is not easy to give the answers.</td>
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<td></td>
<td></td>
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<td>Interesting: you like the exercises, they relate to the lesson.</td>
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<td>Useful: it helps you understand more the lesson.</td>
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<td></td>
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<td></td>
<td>Long: it takes time to answer.</td>
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<table>
<thead>
<tr>
<th>Date:</th>
<th>Time:</th>
<th>How Did You Do This Homework? (X)</th>
<th></th>
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<tbody>
<tr>
<td></td>
<td></td>
<td>I checked my understanding of the lesson through asking myself questions or explaining things to myself, etc.</td>
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<td></td>
<td>I identified the objective of the task.</td>
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<td>I kept thinking while writing and checked what I am producing to see to what extent it makes sense.</td>
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<td>I pay attention to the question, e.g., by underlining keywords.</td>
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<td>I thought about what I have learned in the lesson and what I know to do the task.</td>
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<td></td>
<td></td>
<td>I selected important ideas or information to do the task.</td>
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<td>I used books, dictionaries, encyclopedias, or websites, etc.</td>
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<td></td>
<td>I summarized the lesson.</td>
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<td></td>
<td>I used a given rule.</td>
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<td>I practiced more similar tasks.</td>
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<td></td>
<td>I tried to remember my teacher’s explanation.</td>
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<td>I tried to guess the meaning of words from context.</td>
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<td></td>
<td>I translated words/sentences in Arabic or French</td>
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<td></td>
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<td>I asked my teacher and/ or my classmates for more clarification.</td>
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<td></td>
<td>I worked together with the others to see whether I have understood the lesson or not.</td>
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<td></td>
<td></td>
<td>I communicated to the others what I have understood through for instance participating in class.</td>
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<td></td>
<td></td>
<td>I encouraged myself to overcome my learning difficulties</td>
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<td></td>
<td></td>
<td>I relaxed to lower anxiety.</td>
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<td></td>
<td></td>
<td>I talked about my feelings to my teacher/peers to get their support.</td>
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</tbody>
</table>

**Other Strategies**

<table>
<thead>
<tr>
<th>Date:</th>
<th>Time:</th>
<th>How Was Your Performance? (Tick the Adjective Which Describes Your Performance)</th>
<th>Why Did You Perform in Such a Way?</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Very Good</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>Good</td>
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<td></td>
<td>Poor</td>
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</tr>
<tr>
<td></td>
<td></td>
<td>Very Poor</td>
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</tbody>
</table>
Chapter 12

An Exploration of Darkness within Doctoral Education:
Creative Learning Approaches of Doctoral Students

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ABSTRACT

In doctoral education, the formal structures include the Graduate School system, PhD courses, and supervision contracts, etc. Doctoral education also takes place on informal and tacit levels, where doctoral students learn about the institutional regulations, the research field, academic craftsmanship, and research design by observing how their supervisors talk, act, and handle issues in the professional community. However, the formal-informal divide is not adequate if we want to understand the sprawling, mongrel, and diverse forms of student engagement, coping, and learning strategies within doctoral education today. By drawing on the empirical studies of cross-level institutional voices, as well as international studies into similar grey areas of student learning in doctoral education, this chapter argues that learning spaces of educational ‘darkness’ hold unrecognised potential for enhancing learning experiences, harnessing professional competences, and enriching the depth of research in the PhD life that implies significant contributions to future doctoral education development.

INTRODUCTION AND BACKGROUND

This chapter explores creativity within doctoral education, focusing on the creative learning approaches and learning spaces that doctoral students apply and activate during their PhD life, but which are largely overlooked and ignored within formalised doctoral education. This study applies the concepts of ‘darkness’ and ‘non-formal learning’ to highlight the student activities and learning strategies performed within doctoral education, and links these peripheral activities and learning approaches to concepts of creativity and creative learning. In this way, creative problem solving skills are not something that educators, supervisors, and institutions should invent. On the contrary, they are already existing and ap-

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An Exploration of Darkness within Doctoral Education

plied by the doctoral students themselves in everyday doctoral education, so we just need to catch sight of them and acknowledge their relevance, subtlety, and implications for how doctoral education can be further improved and match doctoral students’ actual needs for support.

The way doctoral education is organised institutionally influences how we expect doctoral students to learn, and therefore also how supervisors approach the task of doctoral supervision. Issues of global drivers including formalisation, massification, and quality assurance, etc. also influence doctoral education. Graduate schools emerge and become still larger entities with the aim of creating administrative cohesion, knowledge sharing across disciplines, and centralised support systems on a divisional level (Andres et al., 2015). The body of literature on how to ensure quality in doctoral education and professionalise the research supervision of doctoral students is growing, including books on how to advice students about writing up their thesis (Murray, 2011; Trafford & Leshem, 2012), how to assess the doctoral thesis (Pearce 2004; Tinkler & Jackson, 2004), and how to guide and prepare doctoral students for the viva (Murray, 2009; Morley, Leonard & David, 2010). The underlying logic of this formalisation of doctoral education rests on the understanding that doctoral education can be a messy process and spin out of control for students and supervisors, which is why doctoral education should be ’tamed’ and rationalised into formalised procedures and contracts.

Students are met with guidance on how to manage their personal circumstances and skills development (Cryer, 2006), and told to “be aware that you must accept the responsibility for managing the relation between you and your supervisors. It is too important to be left to chance” (Phillips & Pugh, 2012, pp. 108). Lee connects this aspect of formalisation with what she calls “functional teaching and supervision” and links it to a “managerial approach” (Lee, 2012, pp. 31). Grant describes formalisation of doctoral education as “a matter of technical rationality” (Grant, 1999, pp. 2), which she argues is “attractive, particularly to university bureaucracies (and their funding bodies) who want predictable outcomes and timely completion” (ibid). Formalisation of doctoral education is enacted to prepare for the unexpected and keep students on the right track by inviting them to document and reflect on their research and learning processes step by step. This is seen in every day doctoral education in the use of electronic logs and evaluation systems, in the rules and regulations of doctoral education in the different national contexts, and in formalised structures such as research programmes, PhD programmes, departmental guidelines, and formalised learning environments such as obligatory and voluntary PhD courses, seminars, and workshops.

In contrast to the formalised ways of organising doctoral education, important parts of doctoral supervision take place as “role modelling” (Fuller & Unwin, 2009). On more implicit and tacit levels, doctoral students learn about the organisation, the research field, academic craftsmanship, and research design by watching and observing how their supervisors talk, act, and handle issues in the academic community. Philips and Pugh (2012) stress that role modeling “is a very important aspect of your task as supervisor. It is not a case of saying ‘do as I tell you’ but more a case of students gradually learning to ‘do as you do’, whether that is what you prefer or not (pp. 191). In this process, the doctoral student – sometimes overtly, sometimes tacitly – learns and assimilates the supervisor’s disciplinary “world view” (Wisker, 2012, pp. 173) and “habit of mind” (Halse & Malfroy, 2010); the way the supervisor ‘sees’ the world of their discipline and acts according to the “lived knowledge that enables individuals to exercise deliberative reasoning to make considered judgments about how to act in particular situations to bring about positive change” (Halse & Malfroy, 2010, pp. 85). On the social level, this aspect of organisation is
An Exploration of Darkness within Doctoral Education

often described, based on the work by Lave and Wenger (Pearson & Brew, 2002, pp. 142), as the way in which doctoral students become part of specific communities of practice and socialised into becoming a scholars (Gardner & Mendoza, 2010; Fuller & Unwin, 2009). Lee (2012; 2008) defines enculturation as “the process of socialization or acculturational into the discipline, the working milieu (e.g. the academic department and the university) and the national culture” (Lee, 2012, pp. 48). A person is ‘enculturated’ “when they [...] have learned the traditional content of a culture and assimilated its practices and values” (ibid.) Even though these informal ways of organising doctoral education are not formalised, they are still obvious and visible to the supervisors, students, administrators, and heads of graduate schools as important and powerful factors in the formation of doctoral students and the expectations regarding how doctoral students learn, struggle, cope, adapt, and find their own voices and become stewards (Golde & Walker, 2006) of their disciplines.

The above described ways of understanding how to organise doctoral education, anticipate students’ learning approaches, and encourage and imprint such learning strategies in the students are often played out as a schism between formal and informal learning. This conceptual duality can be seen as ‘visible’ teaching and learning in contrast to the understanding of doctoral education as something embodied and enacted within disciplinary horizons. However, in the following this chapter argues that the formal-informal divide is no longer adequate if we want to understand the sprawling, mongrel, and diverse forms of student engagement, coping, and learning strategies within doctoral education today. Still more studies emerge that describe the hidden lives and realities of doctoral students, and the often overlooked pluralism of learning activities, which the many doctoral students go through and enact during their PhD life (Hopwood et al., 2011; Jazvac-Martek, 2011; Määttä, 2012; Engels-Schwarzpaul & Peters, 2013).

This includes studies into the influence of student and supervisor ‘idiosyncrasy’ in supervision (Bengtsen, 2012; Bengtsen, 2011), the implications of ‘nested’ institutional contexts on doctoral education frameworks (McAlpine & Norton, 2006; McAlpine & Åkerlind, 2010), and the argument that such overlooked dimensions of doctoral education may hold unimagined potential for creativity in doctoral students’ research (Frick, 2011; 2012; Brodin, 2014). As shown in the author’s previous work (Bengtsen, 2016; Bengtsen, 2014a; Bengtsen, 2014b), doctoral students who do not easily fit into the neat formal-informal divide enact sprawling learning spaces and approaches that are difficult to contain in the language, concepts, and organisational systems of doctoral pedagogy available.

By drawing on an empirical study of cross-level institutional voices and understandings of educational frameworks set up to enhance the quality of PhD education, as well as international studies into similar grey areas of student learning in doctoral education, this chapter argues that such sprawling and mongrel learning spaces of educational ‘darkness’ (Bengtsen & Barnett, 2016) may hold unrecognised potential for enhancing learning experiences, harnessing professional competences, and enriching the depth of PhD research. The keyword ‘darkness’ is used in this chapter to describe learning approaches located in the blind spot of institutionalised and formalised doctoral education. The term does not connote to unwanted or degenerate forms of learning, but is used in a neutral sense to point out the often overlooked and ignored learning strategies, which doctoral students apply when struggling to find their own way and own voice in pursuit of the PhD.

The first two parts of this chapter explore the darkness and non-formal learning approaches and spaces within doctoral education, while the last part argues that these phenomena are linked to an underlying and forceful element of student creativity. The chapter concludes by reconceptualising creativity in doctoral education as consisting of darkness and non-formal learning approaches.
MAIN FOCUS OF THE CHAPTER

Based on the initial considerations above, the research questions for this chapter are: How can the ‘non-formal’ and ‘dark’ sides of doctoral students’ learning approaches be made comprehensible, and in what ways may we see them as resources rather than barriers to creativity when developing doctoral education for the future?

In order to answer these questions, this chapter conducted the following three parts studies:

1. A small-scale case study consisting of 12 qualitative interviews with participants across different organisational levels at the Faculty of Arts, Aarhus University, Denmark.
2. A literature review of empirical studies into similar organisational aspects of doctoral education in an international context.
3. A theoretical study within educational philosophy with the aim of forging a new concept to match the findings in steps 1 and 2 and re-conceptualise creative learning approaches in doctoral education.

Hence, in order to answer the research question this chapter has made use of a research design loop in which the case study informs the literature review, which informs the theoretical study, which in turn leads to a joint conceptualisation and conclusion in the end. The conceptualisation of creativity and creative learning approaches within doctoral education is thus qualified by three different sub-studies, which are serially linked and mutually dependent on each other. In the following, three individual sub-studies will be investigated through a so-called research design loop.

The Case Study

To gain an understanding of how different actors within the university view the way doctoral education is organised institutionally, this study started out by conducting small-scale qualitative interviews with participants (n=12) across different institutional levels of the Graduate School at the Faculty of Arts, Aarhus University, Denmark. The case conducted one interview with the Head of Graduate School, one interview with the Team Leader of the PhD Section (the PhD Administration), five interviews with doctoral supervisors, and five interviews with doctoral students. Each interview lasted between 45-60 minutes. The interviews were part of a larger research project, so only some of the questions addressed specifically how the participants understood and valued the organisational set-up of doctoral education within the larger institutional context. The participants were asked 1) how they viewed the organisational framework within the Graduate School, and the Faculty of Arts more broadly, 2) whether they felt well connected and supported by the different institutional levels, and 3) from which level they drew their primary professional identity.

The interview protocol and methods of analysis were developed from guidelines and coding strategies suggested by Brinkmann and Kvale (2014), McCracken (1988), and Bengtson (2012). The interview protocol was influenced by the two recent reports on quality in doctoral education at Aarhus University (Gudnitz, Bengtson & Keiding 2014; Hermann, Wichmann-Hansen & Jensen 2014), using the reports as a shared point of reference between interviewer and interviewee. The coding and analysis was inspired by the concept of “nested contexts” within doctoral education developed by Lynn McAlpine and Judith Norton (2006; see also McAlpine & Åkerlind, 2010), who pointed out that doctoral education consists of “multiple nested contexts whereby the factors influencing attrition and retention are influenced by differ-
ent stakeholders” (pp. 5). Instead of isolating different institutional and educational contexts, McAlpine and Norton (2006) argue that such contexts are intertwined and operate on the interior of each other as nested within each other’s organisational domain. Linguistic analyses of the embedded preconceptions and discourses (Bengtsen 2012: 123ff.) within each participant’s horizon of meaning helped this study to draw out findings relating specifically to the cross-level semantics within each interview as well as across interviews.

The Literature Study

Based on the findings from the interview study, this chapter undertook a literature review to broaden and strengthen the scope of the research perspective. Key readings were selected from the research and handbook literature in the areas of doctoral education and supervision, which make some points in relation to the many different and, institutionally speaking, unexpected and unnoticed learning approaches to the PhD undertaken by doctoral students. These studies show that much of the infrastructure of doctoral education operates in a shadowy and dark space, caught in a blind spot of traditional ways of organising the PhD. However, this chapter present findings in relation to the overlooked importance and necessity of what has been called non-formal ways of organising and scaffolding doctoral education in order to meet and support more fully the effective learning strategies of doctoral students who fall outside the radar of formal and informal educational patterns.

The Theoretical Study

In writing this chapter, it became clear that a new conceptual vocabulary was needed to further describe the so-called non-formal learning strategies and the students’ own ways of organising their PhDs ‘outside’ the traditional frameworks of formal and informal doctoral education. Accordingly, this chapter decided to draw on notions of liminality, otherness, and darkness within the philosophy of Friedrich Nietzsche (2003; 2005; 2006; 2008) and Emmanuel Lévinas (1987; 2001) in order to gain access to new conceptual territory. Also, this chapter drew on the notion of ‘educational darkness’ within higher education (Bengtsen & Barnett, 2016) in order to conclusively outline the features of what has been termed a ‘dark’ doctoral pedagogy. The theoretical study helped this chapter to conceptualise and critically discuss the range of innovative arguments and the need for future research and developmental work within doctoral education across the globe.

THE CASE STUDY: A MULTILAYERED INSTITUTIONAL PERSPECTIVE ON DOCTORAL EDUCATION

The purpose of achieving a cross-level institutional perspective on doctoral education within the Faculty of Arts through use of interviews was to understand the perspective of each institutional level from its own horizon of meaning and thus not favour any one level. Therefore, the concluding point below about the need for stronger cohesion and mutual commitment between the different institutional levels should not give rise to blame, but rather to further investigation of organisational learning within the institution.

During the interview with the Head of Graduate School (HGS), the author was struck by the degree of organisational complexity and the highly developed infrastructure the Graduate School consists of.
The HGS outlined the connections between the different levels (the direction, administration, PhD Committee, Research Programmes, PhD Programmes, disciplinary and departmental levels, the doctoral supervisors, and the doctoral students) and their mutual links, relations, and dependency. Interestingly, for the HGS this complex infrastructure did not seem overwhelming or confusing; on the contrary, she conveyed great organisational savvy in the sense that she was very well aware of the importance and function of each organisational level in itself. What is important for the HGS when developing doctoral education at Aarhus University is: cohesion, organisational learning, cross-disciplinary collaborative work, and improvement of research environments and facilities for doctoral students. To realise this, the different organisational levels would, ideally, cooperate and complement each other in enhancing and enriching the overall quality and professionalism of the Graduate School:

As we have chosen to have a common Graduate School, I think one of the advantages is that you can view the balances in a broader perspective. For example in relation to recruiting new doctoral students. (…) It is easier to perform that task in a coordinated way when you have a common Graduate School. (…) I also see this happening when we have all the research programme directors gathered to discuss recruitment procedures for the Faculty of Arts as a whole, also with regards to the externally funded scholarships. (…) It’s good to have a research environment where the PhD students influence the workplace. (…) The PhD students invigorate and create progress in the research environments. (Head of Graduate School, Faculty of Arts, Aarhus University).

For the HGS, cross-level institutional forms of cooperation are possible and take place occasionally. At the same time, the HGS acknowledges the importance of centralising some of the power and responsibility in committees (the PhD committee, for example), while also recognising the importance of vibrant and inspiring research environments within the disciplines and she was stressing the fact that doctoral students are key to the realisation of such. The multifaceted and mosaic-like character of the HGS’s perspective consequently makes her consider if she herself (as part of the upper directorial level of the Graduate School) may be perceived as (too) far away from doctoral supervisors and, especially, students in everyday doctoral education.

PhD administration is a perspective that is rarely addressed in doctoral education research. In the interview with the Team Leader of the PhD administration (TLA), it quickly became evident that the PhD administration is in daily contact with a very diverse group of members of the Graduate School, including the HGS, the PhD programme directors, the doctoral supervisors, and the doctoral students. It is the task of the PhD administration to remain neutral and open to all the different institutional levels and not take sides but manage the difficulties that might arise in a fair and legal manner. It is important for the TLA to stress that the PhD administration does not represent the Graduate School but supports the Graduate School by administering its work and procedures:

First of all, we’ve got one Graduate School of Arts, covering all the departments of Arts, and this Graduate School is supported by the PhD Section, the PhD Administration. But it’s very important for me to say that the PhD Administration is not the Graduate School. Many people confuse the two issues with one another. I discover again and again, in all kinds of contexts, that we are looked upon as the Graduate School, but we’re actually not. We are just the administration, and our role is to of course administer the things, the policies, that the faculty chooses to do. (…) In my opinion, the Graduate School is the supervisors, of course very importantly, and of course the PhD students, the PhD programme directors – we
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have 8 at Arts – and of course the Head of the Graduate School. They are the Graduate School. And the Graduate School is actually physically situated all over the faculty, at each department and centre, and we support the Graduate School. (Team Leader of the PhD Section, Faculty of Arts, Aarhus University).

The TLA describes how the Graduate School should be understood as a community of different members with a joint endeavour, and that the Graduate School is not located in one physical place where the members of the administration work but is physically scattered all over the faculty where the members of the Graduate School actually work: the supervisors’ offices, the students’ study environments, the director’s meeting rooms, and so on. What the TLA points out as the greatest challenge is twofold: firstly, getting people to acknowledge this – that they are part of the Graduate School and must take responsibility accordingly – secondly, getting people to meet, exchange ideas and support each other despite the demanding daily work tasks, where departments and student research environments may be scattered all over the city.

Among the doctoral supervisors interviewed, there were differing perceptions of how difficult it is to navigate the complexity of the Graduate School and the entire PhD system within the faculty. Even though one of the supervisors, a research programme director himself, saw the organisational set-up as having no important challenges, the general opinion was that it could be rather challenging for doctoral supervisors to maintain an overview of the many processes, regulations, procedures, and demands that doctoral students need to face during the PhD within the Graduate School context:

Yeah [sighing audibly and laughing]… Sorry for sighing… You definitely have to be aware that you’re just one piece fitting into a larger puzzle. (...) All in all it’s a pretty heavy set-up. And one thing is for me to find my role in that set-up. But I think it’s probably a greater challenge to PhD students, because they are in this whole network of relations that are – I know this is putting it a bit negatively – forced upon them. They enter into this structure, this organisational set-up, and they have to find out how to relate to all these different frameworks. (Doctoral Supervisor, Department of Aesthetics and Communication, Aarhus University).

It is central to notice that for the doctoral supervisors, not only the concern for doctoral students’ way into the organisational complexity of the PhD course was at stake, but also their own role, responsibility, and identity. The doctoral supervisors, this one in particular, on the one hand seem to approve of the heavy set-up, because they can see the bigger picture and recognise the difficulty in managing a large Graduate School; on the other hand, they show concern about the relevance and necessity of such a large and complicated ‘machinery’, or ‘puzzle’, within doctoral education. In the interviews, it became clear that the doctoral supervisors are, and view themselves to be, an important and central part of the disciplinary support and research based supervision, but a significantly less important and powerful part of the overall organisation and institutional scaffolding of the PhD programme within the Graduate School as such.

Among the group of doctoral students interviewed, a few found the organisational scaffolding helpful, experiencing that it gave them a stronger sense of being a visible part of the system and helped them learn to navigate in different institutional settings. However, all of the students in the interviews described more or less extensively the challenges of being part of what they saw as different and sometimes mutually exclusive administrative systems. The students acknowledged the faculty’s aim of integrating doctoral students into various programmes and environments, but at the same time they all experienced some measure of confusion about how to benefit from this complex organisational set-up:
I think there is problem with the PhD structure at the moment. It means that my supervisor has some knowledge of how things are supposed to go. And in other cases, it is the PhD programme leader who is my go-to person. (…) But she has like 40 PhD students that she has to make sure are getting all the points they need and whatever. And I think that’s too much. So, sometimes I feel like a satellite in that set-up. My supervisor … there are some responsibilities that he doesn’t have, so he’s kind of letting that go, as he should, but on the other hand, I’m not sure that anybody else has control of where I’m going. (…) I think all of us [PhD students] feel that we are part of a department, and we are part of an institute, and we are part of a faculty. So, that’s three bureaucracies you have to deal with in some way. And I have an additional one: I have a PhD programme as well that covers three different departments. So, I have four units, and I just think that’s confusing, and you have a problem creating your identity. (…) So, I feel like I’m pushed into a structure where I don’t really belong. (Doctoral student, Department of Culture and Society, Aarhus University).

The doctoral students all sense the ‘bigger’ institutional picture of how the infrastructure of the faculty and the Graduate School, and their place within these, is built up. However, the students do not experience the institutional complexity as an advantage; instead, they see it as a potential hindrance to and disturbance of their everyday research and general activities. As pointed out by the student quoted above, the doctoral student sometimes feels ‘like a satellite’ without any strong anchoring anywhere in the institutional set-up, outside their primary disciplinary connection. The students feel secure and have a strong sense of academic identity within their core disciplinary environments, and in the research supervision provided by their supervisor(s), but the larger institutional scaffolding does not moor their research journey to the formalised structures and support systems available.

We see that each institutional level has its own understanding, focus, and agenda with regard to how doctoral education and the infrastructure of the Graduate School is – and, more ideally, should be, – organised. This shows that doctoral education and the Graduate School as an institutional framework are very much alive with a plurality of opinions and actions within the faculty. However, we also see that the different perspectives are not immediately aligned, and that students rather directly emphasise the challenges of doctoral education from their own individual viewpoint. There seems to be something lacking in the middle, as if the ‘glue’ or cohesive force of the Graduate School is being overlooked or kept at a deeply tacit level. Nevertheless, this chapter will not claim that the institutional framework at Aarhus University is failing or wrong, and it should be highlighted that much is being done to ensure quality and enhance the learning experience for the doctoral students. Also, the effort and competence used to improve learning environments for doctoral students is professional and ongoing, which signals that the choice of expanding the Graduate School may be a legitimate and competent strategy. The point of this study is that there are things that point to links and nested contexts not visible in individual layers when compared, and that the sharing of knowledge and collaborative work within the Graduate School across layers can be further improved. Any articulation of the ‘between-layer-activities’ seems to be almost entirely missing in the interviews. Many of the participants address them as being hard to identify, but think that such activities should be foregrounded more, although it is difficult for them to envision what form and shape such activities might take. The ‘between-layer-activities’ that do exist seem to take place on a tacit and personal level, as an informal network of known and familiar ‘go-to persons’ who make everyday doctoral education run as smoothly as possible. This points to the fact that there is a need for more knowledge about these cloaked and implicit cross-level activities and how they influence the experience of cohesion within doctoral education across the different institutional layers.
THE LITERATURE REVIEW: OUTLAWED LEARNING SPACES AND SIGNS OF CREATIVITY IN DOCTORAL STUDENTS’ LEARNING APPROACHES

Recent studies into doctoral education and supervision question the primacy and ‘untouchable’ position of the role and influence of doctoral supervisors. The support, disciplinary and pastoral, available from the supervisor, institution, or department may not be enough to guide, direct, and support doctoral students in their doctoral journeys towards completion. As McAlpine and McKinnon (2013) state, and as more broadly addressed by McAlpine and Amundsen (2011) and Nygaard, Courtney and Frick (2011), doctoral supervisors are only one form of support that students rely on; “on a day-to-day basis, students depended as frequently on peers, friends, and family as they did on the supervisors, drawing on each relationship for different kinds of support” (McAlpine & McKinnon, 2013, pp. 265). McAlpine and McKinnon show in their empirical study that doctoral students are less dependent on their supervisors when it comes to assessment of their progress during the PhD: “supervisors, while important, are not paramount in the doctoral journey” (McAlpine & McKinnon, 2013, pp. 278). These findings disturb the dominant discourse in doctoral education, which argues that more time at the university and more meetings between supervisors and students are needed. Instead, it calls for a more elaborate doctoral pedagogy that sheds light on all the different variations of learning environments doctoral students are part of, arguing that a pedagogical model should be developed for doctoral supervisors, enabling them to support students bridging the gaps between these different learning contexts.

In a different study, Jazvac-Martek, Chen and McAlpine (2011) made similar findings showing that during their PhD studies, doctoral students depended on many different forms of formal and informal networks and support systems. Doctoral students draw on many different resources, and learn in ways that are not easily translated into a generic and academic mindset. Jazvac-Martek, Chen and McAlpine point to the fact that “a plenitude of supportive and critical interactions occurring beyond the primary relationship with the supervisor. Students in our research were on the whole well networked and depended on these relationships for different kinds of support” (Jazvac-Martek, Chen & McAlpine, 2011, pp. 25). This foregrounds the importance of what happens between supervision meetings, and the need for being able to articulate these forms of doctoral peer support and learning in a pedagogical context, as well as the need to negotiate between these contexts and the institutionalised supervision contexts in order to maximize the learning outcome for the individual doctoral student.

Things happening below the institutional radar, influencing the PhD and the supervisory context for the doctoral student, are what Turunen (2012) calls “snack studies” (Turunen, 2012, pp. 72). In Turunen’s report, ‘snack studies’ denote research activities that doctoral students pursue when they need a time out from their PhD projects to engage more playfully and casually in collaboration with other academics. Despite the fact that supervisors would often disapprove of such activities, fearing it would delay completion and lead to further procrastination, the “snacks were nourishing and opened many opportunities for me [the former doctoral student] both in Finland and internationally” (Turunen, 2012). This points to the often overlooked and shadowy parts of the PhD, where the doctoral students tinker, prowl, mess around, and experiment with extracurricular learning environments and other researchers than the assigned supervisors and the institutionalised supervision context. Another example is Zukas and Andersen’s (2012) study of how a summer school helped to ease up the PhD process in a setting “in which the traditional supervisory relationship and the disciplinary curriculum are deconstructed through intensive group processes” (Zukas & Andersen, 2012, pp. 69). Taking a break helped gain momentum and new energy to invest in the research project.
What is sometimes referred to as ‘ad hoc’ supervision is not typically seen as part of formalised doctoral supervision, but is often valued positively by doctoral supervisors and students. Such instances, when doctoral students meet their supervisor or another academic or fellow doctoral student, sharing their ideas by the coffee machine, the water cooler, in the hallway, or unplanned at conferences and seminars, often prove highly valuable and motivating for students. Even though these encounters and forms of project feedback are not considered part of the supervision or doctoral education in a formal sense, they still influence the doctoral students’ ideas and approaches. Another example is from a Finnish group of doctoral students who drove in a car together to and from their doctoral supervisor, who lived in a city far away from their own homes (Sipilä, 2012). Although not seen as part of doctoral pedagogy or institutionally facilitated peer feedback sessions, the car drives “sparked inspiring brain storms in a full car as we continued to discuss our studies [with the supervisor]. Those drives advanced our postgraduate studies and were fun and useful extra-seminars” (Sipilä, 2012, pp. 23). These forms of ad hoc, or non-formal, peer supervision and feedback are often unfairly seen as part of students’ own time and therefore left out of the pedagogical reflection.

As described by Carter (2014), and Carter and Laurs (2014), the role and identity of the researcher change according to what happens in the private sphere of the student’s lifeworld, and the relational energy and robustness in the supervision context may be influenced by how the doctoral student is perceived, related to, and positioned in relationships outside the university. Traditionally, the private sphere of doctoral students has not been seen as part of doctoral pedagogy, but the last decade has seen more focus on what Kearns, Gardiner and Marshall (2008) call “the secret life of the PhD student” (pp. 77). The support systems outside the institutional realm, e.g. family and friends, often prove vital for completion, and “[w]hile personal lives may rarely be referred to in research on doctoral students, (…) the personal cannot be separated from the academic” (Jazvac-Martek et al., 2011, pp. 19). Even though we have known for several years that the private spheres of doctoral students’ PhD journeys are highly important for the probability of completion (on time) and depth of research, it has not been seen as part of the professionalisation strategies within doctoral education. Hopwood et al. (2011) argue that we know too little about how the private lives of doctoral students influence their research and educational activities. When developing doctoral pedagogy, we usually view doctoral students merely as ‘students’, but they are also, as Hopwood et al. stress, “parents, siblings, daughters/sons, and friends; they have other interests to pursue, health and finance to maintain, and domestic lives to run” (Hopwood et al., 2011, pp. 218). Doctoral students often report that they turn to family members, friends, and other academics as often as to their supervisors for guidance, support and advice during the PhD (Hopwood et al., 2011, pp. 220). This suggests that a more holistic approach must be taken if we wish to understand more fully the diverse and multidimensional lifeworld perspective that contributes to constituting phenomena such as motivation, engagement, inspiration, and creativity in doctoral work.

We see that contemporary empirical studies show that doctoral students draw on support and feedback systems outside the formal and informal educational contexts. Also, the studies show that, when facing challenges, doctoral students find new ways or organising their work, inventing ad hoc and extra-curricular learning strategies that fit their own idiosyncratic learning approaches and styles. This is supported by Brodin’s study (Brodin, 2014) on creativity in doctoral education and the intimate link between risk and achievement in doctoral students’ research projects. Brodin underlines that creativity is possible only if the individual is willing “to take a risk, or to defy conventions, or to fight for ideas that others might scoff at” (Brodin, 2014, pp. 2). Furthermore, Frick (2011) points out the transgressive nature of doctoral research, stating that the “[d]octoral study is inherently creative, as doctoral work
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has to be original, extending the knowledge boundaries of a particular discipline” (pp. 123). However, creativity in doctoral learning trajectories can be a rocky road, and Frick (2011) stresses “the process of becoming sometimes leads to conflict, feelings of in-authenticity, marginalization and exclusion, even though ontological insecurity is a necessary part of the process of becoming” (pp. 127). However, we are still left with unanswered questions such as: to what extent is that which goes on between supervision meetings, and in the private sphere of doctoral students, part of doctoral education and the responsibility of supervisors or institutions? What is clear is that we need a stronger conceptual understanding that can extract the non-formal learning strategies as something important in themselves, not to be assimilated into already known, and only partially successful, formal and informal learning paradigms. This is supported by Frick’s (2011) point that “processes underlying creativity need to be made explicit, if they are to add value to the development of students’ awareness and control in implementing their knowledge creatively in an unpredictable professional setting” (pp. 123). Therefore, attention should be given to how we may start extending and qualifying a vocabulary for the creativity inherent in non-formal learning approaches within doctoral education.

THE THEORETICAL STUDY: THE CONCEPT OF DARKNESS IN DOCTORAL EDUCATION

The present section draws on the concept of darkness developed within educational philosophy (Bengtsen & Barnett, 2016), and the philosophy of alterity and transformation in Emmanuel Lévinas (1987; 2000a; 2000b; 2001) and Friedrich Nietzsche (2003a; 2003b; 2005; 2006; 2008). The aim is to enhance understanding of the pedagogical implications of the findings of non-formal patterns of organisation within doctoral education through theoretical speculation. The theoretical perspectives will help to identify pedagogical possibilities and more flexible support systems relevant in future doctoral education.

Encapsulating educational phenomena caught in a blind spot within institutionalised educational practice, the concept of ‘darkness’ seeks to give meaning to the aspects of higher education caught in the interstices between the formal-informal divide. However, using the term ‘darkness’ “is not an argument for educational dystopia, and the term dark does not connote badness or corruption” (Bengtsen & Barnett, 2016). Thus, our aim “is not to create a dichotomy between light and dark, but to present darkness as something other than, and not contrary to, light; and even with its own virtues” (ibid.). Transferred to the context of doctoral students’ non-formal learning strategies during the PhD, the concept of darkness should be seen as making use of the potential of overlooked and ignored learning processes. The purpose of exploring the notion of darkness within doctoral education is to take seriously, as educational challenges and learning potential, situations, encounters, and ways of organising research work that are otherwise viewed as being ‘outside’ the educational boundaries of the PhD. As shown in the presentations of the studies above, there is a surplus, an excess, within doctoral education, which can be seen in the doctoral students’ non-formal ways of approaching the PhD and in the grey areas of the ‘between-spaces’ of the cross-level institutional mindset between the different layers of the institutional framework of the Graduate School. However, embracing such situations “of educational darkness [and moving] into new spaces of educational twilight is not an easy thing, and engaging with the strained and murky situations (...) often causes professional uncertainty and demands deep personal commitment and toil across all institutional levels” (Bengtsen & Barnett 2016). Therefore, we need to delve deeper into the core of
the conceptual semantics of educational darkness, which is why I shall turn to Emmanuel Lévinas and Friedrich Nietzsche for help.

**Lévinas and the ‘il y a’ of Doctoral Education**

As Lévinas argues, when we give meaning to an understanding of a specific phenomenon, for example how doctoral education is organised, we sometimes forget that many different ways of supervising and learning are taking place without our notice. We only see what our habitual conceptual understanding allows us to see and comprehend. Lévinas challenges us to try to give attention to the ‘otherness’ that also exists, even though we cannot directly conceptualise and comprehend it. Lévinas himself describes this as ‘anarchy’, which designates a presence that is non-rational and non-conceptual and without the mediation of any principle. Lévinas, however, is not against reason or rationality as such, but opposes the form of rationality that reduces difference to sameness and assimilates ‘alien’ forms of learning into that which is known and tested.

What we experience within formal and informal doctoral education, when doctoral students learn creatively and organise their doctoral work in a creative manner, is a form of educational darkness. In Lévinas’ terminology, such educational darkness emerges when a “rip in the (...) endless fabric of existing” (Lévinas, 1987, pp. 52) occurs and darkness pours out to flood the system. As Lévinas points out, such “rips” appear when “a pluralism (...) does not merge into a unity” (Lévinas, 1987, pp. 42); when the institutional mindset strives to comprehend a pluralism that does not merge into a unity and will “plunge into darkness, where it would (...) remain as a operation of that darkness” (Lévinas, 2001, pp. 59). Even though it is a place outside attention, and sometimes comprehension, it is not beyond existing. The ‘il y a’ designates a rift in understanding, a secret passage or trapdoor where “the fact of existing imposes itself where there is no longer anything” (Lévinas, 1987, pp. 47). With a reference to Heidegger, Lévinas tells us that in this state of existing, ‘“nothing nothings’. It does not keep still. It affirms itself in this production of nothingness” (Lévinas, 1987, pp. 49). The studies in above point, to the fact is that the existence of ‘institutional non-existence’ meaning that which lies outside or beyond the formal-informal divide imposes itself on doctoral education as forms of educational darkness.

This is like the ‘il y a’ in Lévinas, where “the absence of everything returns as a presence, as the place where the bottom has dropped out of everything, an atmospheric density, a plenitude of the void, or the murmur of silence.” (Lévinas 1987, pp. 46). This points to one of the core challenges for future doctoral supervision and education: when doctoral students display a strong intuition and skill for working and learning creatively, it is very difficult for the formal and informal paradigms to comprehend and make sense of it. Seen in a Lévinasian perspective, the creative learning approaches and strategies pointed out above do not fit into the operational systems and therefore become ‘dark’ and troublesome to these systems. Similarly: that which seems to move around within the between-spaces of the different institutional layers’ understanding of the meaning and function of the Graduate School is present, even though it is a presence of nothing, or a presence that ‘nothings’. Exactly because this understanding of creativity includes risk, tension, and newness in the radical sense, the doctoral students’ learning approaches may be experienced as completely different and ‘alien’ to the institutional framework that recognises, supports, and assesses them.
Friedrich Nietzsche and the Creation of Values in the Vacuum of Values

With Nietzsche, I argue that the meaning of non-formal learning within doctoral education mirrors the epistemological and ethical condition of confronting ourselves with the abyss and recognising that the abyss, the educational darkness, looks back (Nietzsche, 2008, pp. 578). Behind any mask, says Nietzsche, lurks a deeper and more monstrous form of being, something that does not play by the rules of, in this context, formal and informal doctoral education. The studies above showed a force within doctoral education that lives “‘un-philosophically’ and ‘unwisely’, above all, imprudently, and feels the obligation and burden of a hundred attempts and temptations of life” (Nietzsche, 2008, pp. 606). This is a force playing the “bad game” (ibid.), a game that disturbs habitual thinking and controlled layouts of meaning. This aspect of darkness radicalises the active nothingness in Lévinas’ thought, where, as Lévinas writes, “[darkness] is the very play of existence which would play itself out even if there were nothing” (Lévinas, 2001, pp. 59). In Nietzsche, the things that stir on the other side of reason may unexpectedly erupt in “sudden sparks and marvels” (Nietzsche, 2008, pp. 690), bursting with “evil thoughts!” (ibid.), troublesome and unwanted ideas, or skills, which are rarely and never easily recognised in doctoral education.

When doctoral students learn, act, think, and do research as part of their ‘bad game’, they “make use of a rare and singular measuring-rod, almost a frenzy”; they display “the feeling of heat in things which feel cold to all other persons”, and they seem to possess a power for the “divining of values for which scales have not yet been invented: a sacrificing on altars which are consecrated to an unknown God (...)” (Nietzsche, 2006, pp. 50). In other words: they create values for their preferred research work, coping systems, and motivation strategies that may not yet be comprehensible for the established graduate system. As the studies above suggest, this may include that which – for the formal and informal habitual mindset – is random, haphazard, and improper according to a given disciplinary code of conduct or academic codex. This mirrors Nietzsche’s description in Daybreak of the philosopher as a “subterranean man”, a “solitary mole”, “who tunnels and mines and undermines” and is “working there in the dark” (Nietzsche, 2005, pp. 1). Nietzsche’s philosophy is full of descriptions of emerging into wild and unexpected spaces of thought, which are often derogated and banned by common society and common sense. In The Antichrist, Nietzsche describes an ideal state of being, where we have the “courage for the forbidden; predestination for the labyrinth. (...) new ears for new music, new eyes for the most distant things, a new conscience for truths which have hitherto remained dumb” (Nietzsche, 2003a, pp. 125). This theme is also well known from Thus Spoke Zarathustra, Nietzsche’s heralding of the coming of the Übermensch who “seeks fellow-creators, those who inscribe new values on new tables” (Nietzsche, 2003b, pp. 52). In the present context, this means that the creative learning approaches by doctoral students cannot be judged by the norms applied to traditional learning paradigms. As Nietzsche writes in Thus Spoke Zarathustra, the “noble man wants to create new things and a new virtue”, which makes it, dangerously, possible for the creative thinker to “become an impudent one, a derider, a destroyer” (Nietzsche, 2003b, pp. 71). So, based on the findings in contemporary research into doctoral students’ non-formal, or creative, learning strategies, we should develop a pedagogical concept that recognises and supports such new virtues, especially the seemingly impudent ones.
SOLUTIONS AND RECOMMENDATIONS: FORMULATING A DARK DOCTORAL PEDAGOGY

As follows from the above line of argument, we should question the often implicit causality that links the nature and purpose of fruitful learning within doctoral education to receiving supervision, participating in PhD courses, and becoming a valid member of one’s disciplinary community of practice. That is not to say that there is anything wrong with any of these traditional understandings of learning and enhancing skills during the PhD, but there is more to the story than that. In the following section, my aim is to ‘translate’ the above points about darkness and non-formal learning within doctoral education to a new conceptual framework for doctoral pedagogy.

Recognise “Impudent” and “Unwise” Learning Strategies

As shown in the above sections, doctoral students establish work collaboration and participate in discussion forums with academics and fellow doctoral students who are not part of their ‘own’ PhD programme or research programme within the Graduate School. However, despite being ‘foreign’ to the individual doctoral student’s institutional place of belonging, such partners and mentors often become pivotal to success or failure in the PhD. Doctoral students’ personal hunches and desires for seeking out fruitful research, writing, and thinking environments, locally unknown or unwanted PhD courses, and activities generally not part of the formal curriculum have been shown to be essential for the desired originality and creativity of the PhD (Frick, 2011; 2012). However, such extra-curricular activities and networks are difficult to record and award the students ECTS credits for being part of, just as they are difficult to integrate and fit into, more generally, the formal institutional frameworks. Nevertheless, the disciplinary intuition, power of judgment, and personal engagement displayed in the choices of such ‘off-road’ learning strategies of doctoral students are forceful forms of creativity – “the highest levels of competences and integrity” (Golde & Walker, 2006, pp. 9) within doctoral education – and should arguably be facilitated and acknowledged more openly for their educational advantages.

In order to support, sustain, and facilitate such, in Nietzsche’s words, ‘impudent’ and ‘unwise’ learning strategies within doctoral education, the Graduate School (in the broad sense of the term, including supervisors, research directors, and heads of departments) could promote and encourage more ‘ad hoc’ supervision. ‘Ad hoc’ supervision includes the forms of supervision that are unplanned, spontaneous, and not as such part of formalised and time allocated supervision – such as hallway meetings and incidental encounters between doctoral students and their supervisors, peers, or other academics. Ad hoc supervision is often derogated for being unprofessional, unstable and fragmented, and difficult to defend pedagogically and organisationally because of its random and non-formal character. However, ad hoc supervision is also what might match the doctoral students’ needs for guidance and feedback on the fly, being more tailored to their thinking/writing process. With the aim of supporting and encouraging ‘dark’ learning strategies, ad hoc supervision includes acknowledgment of the importance of pauses and breaks during the PhD, during which the doctoral student may ‘escape’ their research project by participating in extra-curricular PhD courses and activities. Also, it includes temptations and intellectual desires, urging on the doctoral student to, momentarily, take on extra ‘snack’ work outside their own research work. From formal and informal supervisor perspectives, such ad hoc learning and supervision strategies could result in overworked students and superficial feedback, which is no doubt a risk. What I stress here is that ad hoc supervision and ad hoc learning strategies seem to have their own important, maybe even
crucial, potential for enhancing the PhD learning experience. Ad hoc supervision and ad hoc learning strategies should be seen not as something extra or a pedagogical ‘accessory’ within doctoral education, but a substantial feature of hitherto overlooked dark pedagogical potential.

A Taxonomy of Risk-Taking and Self-Overcoming

If the aim of a dark pedagogy is to support, guide, and encourage doctoral students who roam in the periphery of known formal and informal learning spaces, even sometimes slipping into the unknown non-formal learning spaces as described above, we need new roles in which to cast our stereotypical doctoral student types. We simply need a new typology for images of ideal and ‘good’ doctoral students, like we have the Robert-Susan schism (Biggs & Tang, 2007) between the surface learner and the deep learner. Not to say that we can do away with Biggs and Tang’s typology of learners within higher education, and neither should we abandon their taxonomies for learning (Biggs & Tang, 2007). What we need are types and taxonomies that match learning in educationally dark spaces within doctoral education. In order to be able to attain originality and creativity in the research outcome and develop as an independent academic and future steward of the discipline, we know from Cherry (2012) that a good doctoral student should set out on a journey with no clear end goal and aim to reach insights that do not yet exist. In a similar strand of thinking, we find Peelo’s (2011) surprisingly (for a handbook – see my analysis of Peelo’s work in Bengtsen, 2014a) strong focus on the importance of risk in doctoral supervision and education, and the condition of risk as one of the primary drivers in creative doctoral work.

How do we formulate student roles for doctoral study, presupposing that the student role is one of self-transformation and self-overcoming? Based on the studies above, these ideals seem to be implicitly embedded in many of the institutional expectations to doctoral students’ research. But how do we frame this in a typology for learning during the PhD? If we, initially, build on Nietzsche’s vocabulary for the attributes of the Übermensch, we need a taxonomy in which the element of risk in thought and action is more developed and elaborated than in the current taxonomies for learning applied today. If ad hoc learning and supervision becomes a new ideal for disciplinary and scholarly robustness and creativity during the PhD, we should acknowledge, in Nietzsche’s words, that the “devotion of the greatest is to encounter risk and danger and play dice for death” (Nietzsche, 2003b, pp. 138). It is necessary to facilitate learning within doctoral education that enables the students to attain a new disciplinary and academic “overcoming” (Nietzsche, 2003b, pp. 139). It falls outside the scope of this book chapter to outline a more fully-fledged taxonomy for dark doctoral learning, but hopefully this undertaking will grab the interest of educational developers, doctoral supervisors, and heads of graduate schools in the future.

Embracing Institutional Darkness

The final feature of a feasible dark doctoral pedagogy, which I shall put forth here, is related to the need for embracing institutional darkness. This means that an important potential for learning in doctoral education exists in places of abandonment, disloyalty, and chance events. The findings above suggest that it may be fruitful for doctoral students, at times, not to heed the advice of their supervisors when they advise them to stay focused on the thesis and cut down on extra-curricular activities outside the PhD – at the university or in the private sphere (Jazvac-Martek et al., 2011; Hopwood et al., 2011). From the doctoral student in the interview above, we learned that she felt it was OK for her supervisor to let part of the responsibility go, “as he [the supervisor] should”, just like she herself felt it was alright to
turn her back on some of the intended learning environments in the PhD programmes, which seemed irrelevant and too time-consuming for her. This attitude of defiance and resistance is reported by former doctoral students to have had a redeeming effect on their research work (Tulloch, 2013; Oinas, 2012), experienced to release work energy and enhance the creativity in their research approach.

In order to support and sustain the creativity that arises from a dark doctoral pedagogy, supervisors and advice from the Graduate School should more generally encourage doctoral students, if only momentarily, to desert their research projects and pursue stimulation and inspiration elsewhere – in the form of ‘snack studies’ and summer schools, for example. Also, in times of crisis doctoral students should be allowed to show disloyalty to their supervisors and seek the counsel of colleagues, peers, friends, and family, as this approach has shown to be able to put them back on track, albeit in a place they did not imagine themselves. This point links back to the promotion of ad hoc supervision and the resources held in store in what may seem difficult to manage and immediately benefit from in one’s research work. Again, we find support in Nietzsche’s vocabulary and his description of the ‘constructive evil’ (my term). For Nietzsche, evil can be a constructive force when understood as resistance to and overcoming of tradition, normality, and norms. On the background of the findings above, I argue, in Nietzsche’s words, that doctoral students should “[d]elight in petty wickedness [which] spares us many a great evil deed. (...) The evil deed is like a boil: it itches and irritates and breaks forth – it speaks honorably” (2003b, pp. 113). We see Nietzsche giving a strong sense of meaning to chance encounters and elements of good or bad luck, which can be changed to unforeseen resources and learning opportunities. If doctoral students are taught and encouraged to draw more fully on different, and not merely the institutional, support networks and sources of inspiration, they could become open to ad hoc encounters and insights generated by chance – what Nietzsche describes as the “excitation of our imagination brought about at the decisive moment by some immediate, very trivial event (...) [that] happens quite by chance to leap forth (...), which we can never take account of beforehand” (Nietzsche, 2005, pp. 79). Again, it must be stressed that such ‘evil’ ways of navigating in the institutional learning environments should not be seen as a replacement of formal and informal support systems and learning environments. Instead, it should be understood as a way of intentionally and explicitly making non-formal learning approaches part of institutionalised learning spaces. We need to rethink the future institutional learning environment within doctoral education and find ways to integrate the institution with what lies outside, or on the other side of, the institution.

FURTHER RESEARCH DIRECTIONS: THE IMPLICATIONS OF DARKNESS IN DOCTORAL EDUCATION

Before suggesting radical changes to current practice within doctoral education today, sober, critical reflection on the points I have made so far should prove helpful. Firstly, it is relevant to consider whether a ‘dark pedagogy’ is unintentionally working against, rather than complementing, traditional formal and informal ways of organising doctoral education. One could argue that embracing educational darkness in the PhD is an unknowing attempt to make a doctoral pedagogy out of what has before been proven to make students drop out of their PhD. In some contexts of understanding of good learning approaches to the PhD, doctoral students are often advised to make a clear cut between their professional supervisor and support systems related to the work of the Graduate School, and the private, non-academic support systems and advisers (e.g. professional networks outside academia, friends, and family).
students often by default hold their supervisors in great esteem, as experts within the field and role models within the discipline, and for many doctoral students it would be considered counterintuitive and inappropriate to suggest that they should put less faith, while maintaining the amount of attention and respect, in their supervisor’s powers when it came to completion. Likewise, new doctoral students on obligatory induction programmes run by the Graduate School at Aarhus University are typically told that they should avoid procrastination, try to stay focused on their own project, try not to be tempted to work on other research projects during their PhD, and generally try not to take too many risks during their PhD, as the primary purpose is to obtain the degree. In this perspective, a dark pedagogy does not seem the sanest of choices.

Furthermore, the conceptual underpinnings of a dark pedagogy should be taken into critical account. As I have argued elsewhere (Bengtsen, 2012), the points about resistance and risk-taking in doctoral students’ learning approaches could be seen as underlying quasi-romantic, maybe even masochistic, ideals about hardship and individuality as the driving forces of good scholarship. This ‘hero cult’ could be said to stand in opposition to current findings regarding the importance in doctoral education of collectivity and systems of group feedback and peer support. Finally, it can be asked what will happen conceptually if the darkness of doctoral education is successfully drawn into the ‘light’, becoming part of good educational practice during the PhD? Does the potential of educational darkness disappear if it becomes assimilated into current educational practice? Is it at all possible to work authentically from a notion of darkness and develop constructively, rather than only negatively, a new conceptual foundation on which to form future doctoral education?

These questions cannot easily be done away with, and working with a dark doctoral pedagogy one should take them seriously in an ongoing critical dialogue. However, the obvious challenges aside, it is necessary that institutional frameworks surrounding and upholding doctoral education are rethought to match the actual, non-formal learning strategies of doctoral students today. This should not be done with the aim of undermining current formal and informal practices, but with the purpose of developing and enhancing the forms of support and supervision available to doctoral students within future doctoral education programmes. How this can be concretely imagined and done should be the topic of future research projects into contextual doctoral education settings within specific regions and countries, as we know that national and regional contexts vary greatly regarding the institutional scaffolding of the PhD (Andres et al., 2015). From this argument follows that the institutional frameworks described in the studies presented in this chapter need to be further developed to meet the contextual and individual needs of specific students and specific research projects and processes. What the formal institutional perspective of the graduate school, and the informal perspective of the discipline, see as a comprehensible understanding of learning approaches and strategies by doctoral students does not completely match the reality, and the creativity, of actual doctoral students’ experiences. Formal institutional and informal disciplinary mindsets and resources should better match the creativity of doctoral students’ learning approaches. This could take the form of cohort mentoring, as pointed out by Mullen and Tuten (2010), and external coaching, as pointed out by Godskesen and Kobayashi (2015), both of which are educational formats that may link formal and informal learning platforms within doctoral education in fruitful and innovative ways.

This means that if the role of the supervisor changes to a less absolute pedagogical force within doctoral education – something this study suggests could be of importance – the role of the Graduate School changes as well. Today, the role of the supervisor is very dominant in everyday doctoral education, but if it was pushed a bit into the background, the Graduate School as such would, presumably, become more
foregrounded. This entails that the plurality of levels, actors, and support systems of present-day Graduate Schools should be better aligned and reach a higher level of cohesion and complementarity. If the role of the supervisor were to become ‘merely’ one of many, rather than necessarily the learning platform for doctoral students, the other learning platforms within the Graduate School would be made visible, comprehensible, and relevant to doctoral students in new ways. This would allow for the creativity and innovation of doctoral students’ learning approaches to be met, supported, engaged, and enhanced by the entire Graduate School rather than only by the supervisors.

CONCLUSION

This chapter has focused on studies into the creative nature of doctoral students’ learning strategies, the darkness of the institutional infrastructure, and the future role of the supervisor within doctoral education. Overall, it can be concluded that more research is needed to understand the complexity and myriad of links across different institutional layers of the large Graduate Schools in present day doctoral education. These organisational and institutional layers and levels can be better aligned and mutually strengthened to build stronger momentum and cohesion within the range of support systems made available to doctoral students in different pedagogical areas of expertise. More specifically, the following conclusions can be drawn:

Doctoral students, and typically their supervisors as well, sometimes feel a lack of commitment to their Graduate School, wherefore it is a challenge in future doctoral education for Graduate Schools to make themselves visible, accessible, comprehensible, and relevant to doctoral students and their supervisors. A first step could be to encourage a stronger sense of ownership in the supervisors and students themselves and invite them to use their voices, power, and responsibility to improve and develop the structures, work, and activities within Graduate Schools today. Doctoral students lack reasons to familiarise themselves with the many different support and feedback options offered in a large and complex Graduate School. However, students should have a clear, disciplinary-driven interest and motivation to do this. Further, the levels of the organisational infrastructure and institutional set-up should be better aligned and have a mutual understanding of each other’s educational work, purpose, and competences. This entails that we should readdress the function, range, and scope of the supervisor role within doctoral education. As I have argued, the formal and informal understandings of the role, importance, and function of the supervisor do not match the non-formal and diverse student initiatives, coping strategies, and learning approaches in present-day doctoral education. The variety of support, feedback, and inspiration that doctoral students draw from raises the question of whether the meaning of doctoral supervision should be expanded to cover different forms of supervision and feedback carried out by different actors and institutional levels during the PhD. No matter what forms, turns, and changes will be made in future doctoral education, it is of chief importance that the creative excess of present day doctoral students’ learning strategies and approaches to their work, and to the PhD in general, must be better ‘cropped’ by the doctoral education system – so that the infrastructure of Graduate Schools may develop institutionally with and not against the doctoral students. With a term borrowed from Ronald Barnett (2013), we should think more ‘ecologically’ about doctoral education environments in the future. This means that in order to improve and enhance the quality of future doctoral education, the different layers of the Graduate School, or the institution, should collaborate more coherently to benefit doctoral
students. Also, it means that doctoral pedagogy should not only be outlined from the perspective of educational strategy but grow out of the creativity and inventiveness of individual doctoral students.

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An Exploration of Darkness within Doctoral Education


**KEY TERMS AND DEFINITIONS**

**Creative Learning:** Learning that surprises and challenges the traditional, or conventional, understandings and enactments of learning within a given institutional context.

**Cross-Level Institutional Perspective:** A research approach that explores several levels, or layers, of the organisation or institution in the same study, with the aim of conducting a comparative analysis of these levels.

**Darkness:** A term describing that which lies in a blind spot for the institution or discipline regarding challenges, opportunities, and activities that may be a central part of the doctoral experience.

**Doctoral Pedagogy:** The teaching and counselling strategies used by doctoral supervisors in their doctoral supervision. A doctoral pedagogy specifically builds on underlying understandings of learning and teaching.

**Formal Learning:** Learning activities and approaches clearly defined and initiated by the institution and Graduate School – usually in the form of courses and supervision.

**Informal Learning:** Learning activities and approaches tacitly defined and initiated by the discipline and disciplinary community of which the student is part.

**Learning Environment:** The physical spaces, facilities, locations, and technologies offered students as work spaces and areas.
Non-Formal Learning: Learning activities and approaches defined and initiated ‘outside’ the formal and informal learning environments, e.g. enacted in or influenced by the private sphere (life world) of the student.
Chapter 13

Integrating Creative Thinking Skills into the Higher Education Classroom

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ABSTRACT

The Torrance Incubation Model (TIM) provides a simple and highly effective mechanism for integrating creativity into the teaching of any subject. The model provides guidelines for educators who wish to develop their students’ creative skills, but struggle to find the space in the curriculum in which to teach creativity as a subject. The TIM allows creativity to be woven into lesson plans by deliberately incorporating one, or more, of the core creativity skills identified by Torrance. This chapter explains the TIM, and provides examples of how it was used to redesign lessons in a higher education class, in order to teach both the subject, and at the same time develop the students’ creative capabilities.

INTRODUCTION

Creative thinking and problem solving are essential skills for the 21st Century workplace (Adobe, 2014; National Center on Education and the Economy, 2008; Partnership for 21st Century Skills, 2008; Trilling & Fadel, 2009). However, an alarmingly low number of K-12 schools are teaching creative thinking skills to our future university students (Adobe, 2013). This, of course, means that the responsibility for developing the skills is passed on to higher education instructors.

If higher education accepts this challenge, individual faculty members will face two big questions: How do I do it? And, when do I find the time to do it with an already-packed syllabus? Fortunately, this chapter has a potential answer that covers both questions.

For over twenty-five years, the faculty at the International Center for Studies in Creativity at Buffalo State have been using a curriculum design method called the Torrance Incubation Model (TIM) (Mur...
dock & Keller-Mathers, 2002; Torrance, 1979a & b; Torrance & Safter, 1990; 1999;) for the creation of their graduate courses. While this model was originally designed for K-12 educators (Plooster, 1972; Torrance, 1979a) it has been applied in numerous higher education classes with great success (Murdock & Keller-Mathers, 2008). TIM provides a three-stage framework, along with a list of creativity skills, that enables the instructor to marry content and creativity together in a single design, thereby neatly answering the ‘how’ and ‘when’ questions.

The purpose of this chapter is to introduce the Torrance Incubation Model, examine how it has been adapted for higher education classes, and give specific examples and case studies that highlight the benefits of applying the TIM to the problem of designing an engaging curriculum that serves the dual purpose of teaching the content and developing students’ creative thinking skills.

BACKGROUND

TIM as a Classic Framework for Integrating Creativity into Content

E. Paul Torrance, who was known as the “father of creativity in education” (Millar, 2010), originally developed the Torrance Incubation Model of Teaching and Learning (TIM) for K-12 educators (Clymer, 1969; Torrance, 1979a). Torrance understood that with limited time and a curriculum that was already packed with essential content, as well as remedial and enrichment activities, teachers were not going to turn their focus to creativity – an area that might appear to be an “extra.”

Torrance had been considering this problem since the 1940’s. However, it wasn’t until he was asked to act as the learning consultant for the Ginn Reading Series (Clymer, 1969; Plooster, 1972) that he crystallized his thoughts and produced the first version of the TIM. His key insight was that rather than providing activities that might be used in addition to the Series, he could design a learning curriculum that wove the creativity skills directly into the existing lessons. At its heart, the TIM is a way to help educators create lesson plans that extend the creative thinking skills of their students at the same time as teaching the disciplinary content.

Although TIM contains the word “model” in its title, if it were being developed today, Torrance might describe it as a learning design process. As with any such process, the user enters into the TIM with a specific content goal in mind; for example, “students will describe a simple model of photosynthesis”. Where Torrance’s model differs from other design processes is that it then encourages the user to incorporate a second objective. This additional objective is a creativity goal that is drawn from the list of 18 creativity skills that Torrance (1979b) regarded as critical to the development of creative individuals. The amalgamation of these two objectives becomes the input to the core of the TIM. The output from the TIM is a lesson plan that both teaches the content, and delivers it in a manner that develops the associated creativity skill.

Torrance’s model identifies three major stages that are common across any lesson (see Figure 1). The stages are: Heightening Anticipation, Deepening Expectations and Extending the Learning.

The choices made within these broad stages establish the arc of the lesson design, and the selected creativity skill sets the “tone” or the manner in which it will be delivered. The three stages are described in greater detail later in this chapter. At this point it is only necessary to understand that the TIM provides educators with a framework for developing creative thinking skills while teaching content in a way that strengthens the lessons and engages students in meaningful learning experiences. It is designed to set
the stage for incubation to occur beyond the time frame of the lesson, given the deep engagement of the lesson itself.

**Introduction to Creative Thinking Skills**

The standard, scholarly definition of creativity is the “generation of novel and useful ideas” (Runco & Jaeger, 2012; Stein, 1953). However, while the definition may be accurate, it doesn’t really help people “be” creative. Creativity is a skill, or perhaps more precisely, a set of interlocking skills. And like any skill, developing one’s creativity involves guided, intentional practice. But what should educators be encouraging their students to practice? Given that creativity is a complex and multifaceted topic, it’s not surprising that researchers have identified a number of different but overlapping sets of skills. In this section the authors will briefly introduce some of the skill sets with a focus on Torrance’s set. This is partly because it has proven to be so effective, but also because - in the authors’ view - providing educators with an ever widening list of skills doesn’t necessarily help them teach more effectively. At the most basic level, it probably doesn’t matter which skill you choose to adopt, but it matters greatly that you implement that chosen skill in your classroom.

The authors start the review with the seminal work of J. P. Guilford (1956). Guilford was a past president of the American Psychological Association and a noted creativity scholar. In fact, it is his...
Integrating Creative Thinking Skills into the Higher Education Classroom

1950 inaugural address to the APA that is credited with kick-starting a great deal of creativity research. Guilford (1956) summarized his set of creativity skills with the acronym FFEO.

**FFEO Stands for**

- **Fluency:** The ability to generate a lot of ideas,
- **Flexibility:** The ability to generate diverse sets of ideas,
- **Elaboration:** The ability to elaborate on a given idea, and
- **Originality:** The ability to generate one or more new ideas.

This simple but powerful list of skills provides an excellent starting point for understanding the basics of divergent thinking, which is an essential aspect of creativity and problem solving processes. However, it is at best only a partial list of the skills demonstrated by creative people.

Torrance built upon Guilford’s work by developing an extended set of skills that more accurately captured the repertoire of behaviors that he observed in the children he studied (Millar, 2010; Torrance, 1979b). Torrance’s eighteen core skills, outlined in the book *Making the Creative Leap Beyond* (Torrance & Safter, 1999), form the basis of the skill set used by the authors in their work in higher education.

Table 1 outlines the eighteen skills, and provides a brief explanation for each one. In the rest of this chapter, the authors will explore a subset of these skills in greater detail.

Although this list provides a multi-faceted view of creative thinking skills, it is certainly not exhaustive. For example, Williams (1970) developed a thinking and feeling model that included Guilford’s four cognitive skills, stated above. In addition, Williams outlined four affective skills including curiosity.

### Table 1. The leap skills

<table>
<thead>
<tr>
<th>The Problem</th>
<th>Produce and Consider Many Alternatives</th>
<th>Be Flexible</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aware of a challenge or opportunity; define problems.</td>
<td>Fluency; generating many options.</td>
<td>Generating variety, different categories and perspectives.</td>
</tr>
<tr>
<td>Be Original</td>
<td>Highlight the Essence</td>
<td>Elaborate-But Not Excessively</td>
</tr>
<tr>
<td>Statistically infrequent responses; novel, unusual perspectives.</td>
<td>The absolutely essential; synthesizing all, focusing on one.</td>
<td>Adding or developing details or ideas.</td>
</tr>
<tr>
<td>Keep Open</td>
<td>Be Aware of Emotions</td>
<td>Put Your Ideas in Context</td>
</tr>
<tr>
<td>Resisting premature closure.</td>
<td>Recognizing cues, understanding through feelings.</td>
<td>Putting parts of an experience into a bigger framework.</td>
</tr>
<tr>
<td>Combine and Synthesize</td>
<td>Visualize It - Richly and Colorfully</td>
<td>Enjoy and Use Fantasy</td>
</tr>
<tr>
<td>Putting together new connections with the given elements.</td>
<td>Using vivid, colorful imagery.</td>
<td>Imagine, play and consider the nonexistent.</td>
</tr>
<tr>
<td>Make It Swing! Make It Ring</td>
<td>Look at It Another Way</td>
<td>Visualize the Inside</td>
</tr>
<tr>
<td>Using kinesthetic, auditory senses; your full range of senses.</td>
<td>Seeing from a new or different visual or psychological perspective.</td>
<td>Describing the inside of things; seeing internal dynamic workings.</td>
</tr>
<tr>
<td>Break Through - Expand the Boundaries</td>
<td>Let Humor Flow and Use It</td>
<td>Get Glimpses of the Future</td>
</tr>
<tr>
<td>Changing the paradigm; going outside given requirements.</td>
<td>Responding to incongruities, surprises, discrepancies.</td>
<td>Wonder, dream, explore possibilities that do not yet exist.</td>
</tr>
</tbody>
</table>

Adapted from Torrance and Safter (1999)
Integrating Creative Thinking Skills into the Higher Education Classroom

(willingness), risk taking (courage), complexity (challenge), and imagination (intuition), described as student behaviors.

Amabile (1996) also outlined additional creativity skills, including tolerance for ambiguity, intrinsic motivation, risk-taking and what she referred to as “set breaking,” or thinking outside the box. Additionally, Puccio, Mance and Murdock (2011) posited additional cognitive skills that included diagnostic, visionary, strategic, ideational, evaluative, contextual and tactical thinking, and affective skills that included mindfulness, dreaming, sensing gaps, playfulness, sensitivity to one’s environment and tolerance for risk taking that are central to creative problem solving.

As the reader can see, there is no shortage of skills to choose from, and the authors encourage you to use these lists as lenses through which to view your students’ typical behaviors. The authors have found that using these lists has thoroughly helped identify which skills might be particularly useful to develop for each year’s class.

Creative Thinking Skills in the Classroom

Having access to an inventory of skills certainly helps faculty answer the ‘What are we going to teach?’ question. And if time permitted, it would be perfectly valid for educators to pick one skill to teach and practice in their classrooms as the main content of a lesson. For example, by making time to teach the guidelines for divergent thinking (Puccio, Mance & Murdock, 2011) and having students generate possible ideas for a perfect desk, the educator could teach fluency. Equally, by showing students two random objects and asking them to generate solutions to a problem with the objects, the educator could teach originality. In Table 2, you will see an example of a skill that is taught as a lesson.

The problem is that while these may be highly beneficial to students (Torrance & Safter, 1999), teachers often do not have the time in class to teach an additional topic area. Furthermore, as mentioned earlier, developing creativity requires consistent, guided practice. Just because an educator has time this week, doesn’t mean that he/she will have the opportunity to continue this approach for the rest of the semester.

Fortunately, by deliberately integrating a creativity skill into a lesson plan, an educator can seemingly stretch time and achieve two learning objectives in one lesson. In essence, it is the same as teaching mathematics while playing basketball, or presentation skills as part of a literature class. The only difference is that most educators are not familiar with the creative skills model, and therefore the techniques may seem strange at first. But even limited exposure to the approach should reassure any educator that these ideas are essentially common sense. For example, literature professors could ask their students to write alternative endings for an assigned book (Produce and Consider Many Alternatives). A biology class could explore how plants might harness solar energy on different types of planets (Get Glimpses of the Future). A philosophy professor could have his students imagine what the world would be like if we were all one gender (Enjoy and Use Fantasy).

Applying the skills list to individual disciplines should result in at least a few ideas for ways in which educators could combine content and skill objectives into a lesson plan. In fact, it wouldn’t be surprising for many teachers to discover that they are incorporating a variety of these skills already. However, even for the most imaginative educators, there will be dry patches where they can’t think of effective ways to combine the content with the skill. Fortunately, this is where they can tap into their colleagues’ creativity.

Burnett and Figliotti (2015) interviewed over a hundred educators and creativity experts from across disciplines to uncover over 750 tips and ideas on how to deliberately weave creativity into any curriculum. The following are some examples of the ideas they discussed.
Table 2. Lesson plan: Highlighting the essence

<table>
<thead>
<tr>
<th>Heightening Anticipation</th>
</tr>
</thead>
<tbody>
<tr>
<td>• The cartoon “Leming to the Sea” by Gary Larson is displayed as students enter the room. The instructor shares that this cartoon demonstrates the essence of the belief that being aware of one’s surroundings is important to proactive problem solving.</td>
</tr>
<tr>
<td>• A newspaper is displayed that shows an example of proactive problem solving of some kind. The title of the article represents the essence of what the article is about.</td>
</tr>
<tr>
<td>• The purpose of the lesson is shared (to help students be more aware of and practice this important skill represented in Torrance’s classic studies of creativity.) Torrance &amp; Safter (1999) stated, “Many otherwise highly creative people fail to solve problems or produce really worthwhile creative products because they lose sight of what is important or essential” (p. 98).</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Deepening Expectations</th>
</tr>
</thead>
<tbody>
<tr>
<td>• The definition of Highlight the Essence is shared: “The process of extracting or recognizing the dominant theme or idea from a pool of data.”</td>
</tr>
<tr>
<td>• Small groups are given two cartoons with the captions removed. They are instructed to select one of them and Highlight the Essence of what the cartoon is saying to them by adding a caption or a title. There is a community share-back of the interpretations of the cartoons.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Extending the Learning – Keeping it Going</th>
</tr>
</thead>
<tbody>
<tr>
<td>• In groups, reflect back on the quote: “‘Many otherwise highly creative people fail to solve problems or produce really worthwhile creative products because they lose sight of what is important or essential” (Torrance &amp; Safter, 1999, p. 98). Students share back examples of experiences in which they lost sight of what was important.</td>
</tr>
<tr>
<td>• The following quote is displayed: “Highlighting the essence involves a process of abstract thinking that is rather difficult to describe. It includes identifying the information at hand, discarding erroneous or irrelevant information, refining ideas, abandoning unpromising facts, establishing priorities, recognizing irrelevant or solutions, allowing a single problem or idea to become dominant and synthesizing all of this at the same time. The ‘aha’ experience may be the closest to a more simplified identification of all that comes together in highlighting the essence” (Torrance &amp; Safter, 1999, p. 99). Students identify an application of the skill “Highlight the Essence” in their lives and share how they see themselves using the skill in the future.</td>
</tr>
</tbody>
</table>

Examples of Ideas Discussed

- Produce and Consider Many Alternatives: Ask students to think of many different ways they could explain a class topic to another person (p. 41);
- Enjoy and Use Fantasy: Pose the question, “What would you do with a time extender device?” (p. 56);
- Highlight the Essence: Have students write a tweet (140 characters or less) to highlight what they learned (p. 63);
- Look at it Another Way: Ask students to retell the story in another genre (p. 73);
- Be Original: Ask students to write a paragraph backward, like da Vinci did (p. 101);
- Be Aware of Emotions: Talk about the psychological environment of the classroom. What makes for a trusting environment? (p. 113);
- Make it Swing, Make it Ring: Let students draw to the rhythm of music (p. 123);
- Keep Open: Try an experiment that has potential to work (or not). Ask the students to keep open (p. 133);
- Get Glimpses of the Future: Ask, What will not change in the future? Why not? (p. 145);
- Breakthrough Extend the Boundaries: Have students pick a superhero and think about how he/she might solve the problem (p. 158);
The resulting publication is now in use by many teachers, and the results have been very encouraging. Amalgamating content with skills is not difficult, doesn’t force a compromise between content goals and creative thinking and can actually make classes more engaging and enjoyable.

**THE THREE STAGE TIM FRAMEWORK**

Simply integrating creative skills into lesson plans can have a transformative effect upon students. However, the TIM offers a significantly more powerful way of achieving our learning goals. Earlier, the authors mentioned that the arc of a lesson is built upon 3 major stages: Heightening Anticipation, Deepening Expectations, and Extending the Learning (see Figure 1). Many learning design processes talk about similar phases, and Torrance did not work in isolation as he was influenced by educational theorists, his colleagues in the field of creativity such as Calvin Taylor and Alex Osborn and his teacher Jacob Mareno. Where the TIM differs significantly is that it provides a mechanism for the educator to weave a chosen skill throughout the entire learning process.

In order to show the power of the TIM, the authors will describe each of the stages, and then show examples of how they have used the model to redesign learning sessions at the university level. The examples will highlight typical teaching methods. It is important to recognize that these are simply snapshots of what worked for the authors, in their context. If the approaches seem appealing, educators should feel free to duplicate them for their students, but needn’t regard them as in any way prescriptive.

**Heightening Anticipation**

Before and/or at the beginning of a learning experience, something must occur to prepare the learner to engage in the content. Torrance defined a set of ‘descriptors,’ which were intended to encourage teachers to think about the various dimensions in which they could engage the future learner (Torrance & Safter, 1990). These descriptors, which are probably best treated as prompts, include:

1. Create the desire to know,
2. Heighten anticipation and expectation,
3. Get attention,
4. Arouse curiosity,
5. Tickle the imagination and

The final prompt, setting the purpose and motivation for learning, is a must – especially for adult learners (Knowles, Holton & Swanson, 2012) – as it connects what is expected of the learner with something meaningful in his or her life. The other descriptors in this stage can be used in any combination with ‘giving purpose and motivation’ to strengthen teaching. Instructionally, the items are used to design the learning in a way that meets the content goal (and integrates some aspect of the creativity concept or skill as well). Examples of this will be provided later in the chapter.
Deepening Expectations

During Deepening Expectations, the learner is engaged in one or more of eight cognitive behaviors to deepen engagement in the content. The purpose is to participate in challenging thinking, which is often uncomfortable and requires tolerance for the unknown and risk taking in both the teacher and the learner. Torrance developed a set of evocative metaphors that complement the cognitive behaviors (Torrance & Safter, 1990). Interestingly, the metaphors have quite a polarizing effect, with some users finding them extremely helpful, and others experiencing confusion and annoyance. The metaphors have been included in this section, and the reader is encouraged to consider them, in the hope that they may be helpful, but not to feel wedded to them.

Cognitive Behaviors with Corresponding Metaphors

1. Diagnosing difficulties, synthesizing, integrating and elaborating on information (Digging Deeper);
2. Deferment of judgment and staying open, scanning and searching and evaluating information (Looking Twice);
3. Engaging all of the senses (Listening for Smells);
4. Guessing, correcting, modifying, refining and understanding one’s hunches and feelings about the information (Crossing out Mistakes; Talking/Listening to a Cat);
5. Summarizing, focusing and finding the essence by simplifying and discarding what isn’t necessary (Cutting Holes to See Through);
6. Avoiding the irrelevant or useless, making the best solution better and formulating a problem statement or implementation plan (Cutting Corners);
7. Dealing with difficult subjects, searching for unanswered questions, being overwhelmed by complexity and being absorbed in the information (Getting in Deep Water); and
8. Solving the unsolvable, going beyond the ordinary and opening up new areas (Getting out of Locked Doors) (Torrance, 1979a).

The cognitive skills are intended to serve the dual purpose of helping to design the learning in accordance to the content goal and integrating some aspect of the creativity concept or skill into the Deepening Expectations stage of the TIM, much like Heightening Anticipation.

Extending the Learning

Completing a class and finding that students ‘get it’ it is a very satisfying sensation. But discovering days later that students are still thinking deeply about the topic, have read other papers and have gone beyond the initial concepts and have begun making connections to their lives makes the teaching process nothing short of wonderful!

Torrance was a firm believer in the importance of extending the learning beyond the end of the class. And he saw this as being closely related to the process of incubation, thus the inclusion of the word in the TIM. Unfortunately, incubation can be a difficult concept to quantify, and faculty members are therefore often reluctant to include it as part of their learning designs. After all, it is hard to tell whether students playing Ultimate Frisbee are really incubating on their Mathematics of Parabolas lecture, or just
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enjoying their time outdoors. Fortunately, Torrance provided a series of strategies, along with associated metaphors, to help educators design for incubation.

The key principle underpinning this third stage of the TIM is that learning through incubation occurs most powerfully when the students begin to connect what they have learned with their possible futures. Torrance (1979a) developed five strategies to help faculty members make those connections.

Strategies and Associated Metaphors

1. Using humor and playfulness (Having a Ball);
2. Making the learning meaningful to you in a personal way (Singing in One’s Own Key);
3. Imagining, using fantasy and searching for the ideal (Building Sand Castles);
4. Finding resources and connecting with people, places and other resources (Plugging in the Sun); and
5. Enriching and expanding your view of the future (Shaking Hands with Tomorrow).

It is important to realize that, unlike the creativity skills, the TIM strategies (for all three stages) are designed to be combined in interesting ways. So educators should feel free to select one or more of these strategies to design the final stages of their lessons. Using the TIM in this way promotes incubation and provides a means to enhance creativity while staying on course with the curriculum.

USING TIM IN HIGHER EDUCATION: PRACTICAL EXAMPLES

For more than twenty-five years, the faculty members at the International Center for Studies in Creativity at Buffalo State have been using TIM to design and redesign their undergraduate and graduate courses. Their experiences have shown that the TIM is just as relevant to the higher education classroom as it is to other levels of learning (Murdock & Keller-Mathers, 2008).

Perhaps not surprisingly, many of the Center’s students have also adopted the model for their own work, and Murdock and Keller-Mathers (2008) have collated some of these applications in order to provide a richer range of teaching examples. A subset of these case studies is summarized in Table 3. The stories captured in this list help to show the breadth of contexts in which the TIM can be successfully applied, but they still don’t explain the explicit details of how one puts the model into practice. For that reason, the next section of this chapter is devoted to showing several examples of how the authors redesigned their own courses, along with other examples that show the sort of alternative designs that would emerge from selecting a different creativity skill.

Drinking Our Own Champagne

For the last fifteen years, the authors have been teaching - often in collaboration- a graduate level course titled CRS 560: Foundations of Creative Learning. The course is intended to provide students with an introduction to the works of the classic scholars in the field of creativity. The course has been delivered for 33 years, and was originally designed to be taught in a traditional manner (a mix of experiential learning and lecture, delivered as a night course in a three-hour-per-week block over a semester).
The course is currently taught in a variety of formats, including one night a week over the course of a semester, a weekend format that consists of one weekend a month for four months and a blended course in either of the above formats where a portion of the class is online rather than seated. It is also offered as a six-day institute for a cohort of students from all over the globe who converge in Buffalo to take the course as part of a State University of New York certification program in Creativity and Change Leadership (http://creativity.buffalostate.edu/masters-program). This intensive six-day seated format is buffered by online segments, prior to and following the seated portion.

After several years of teaching the course in the typically academic way, and with the added incentive of making the intensive format for distance students more powerful, the authors decided to revamp the entire offering, using the TIM for both an overall framework, as well as for individual lessons. Below is an overview of the entire course using the TIM framework, as well as three lessons delivered within the course. Although this format is used in different timeframe delivery modes with modifications, the specific format described below is the framework the authors use with the distance students who are taking the intensive six-day seated format. Additionally, there is an alternative lesson with the same content goal but different creativity skill to show the reader how the lesson might be set up.

**OVERALL CRS 560 COURSE DESIGN**

CRS 560: Foundations of Creative Learning has had aspects of the TIM woven in since Dr. Mary Murdock, a student of Dr. E. Paul Torrance, began teaching the course as a faculty member at ICSC in 1987. Yet the authors, given the challenge of preparing students adequately at a distance to fully engage in a deep way during the six day seated portion of the course, continued to develop the course to fully use the TIM as the delivery system. This provided a way to both teach creativity skills while teaching other content and deepen the learning more effectively. The original design and the TIM design for the course are discussed next.
Traditional Course Design

The original, more traditional course was designed with many learning outcomes and a list of topics to be delivered within the course. The topics were delivered in a sequential manner. Below is a representative sample of goals and topics from the course.

Course Description

This course provides an introduction to theory and research in the field of creative studies. The focus is on knowledge and understanding of creative learning models and theories.

Student Goals

- Apply select theoretical definitions, principles and assumptions in the creativity literature.
- Identify basic organizational schemas, frameworks and families of theories and select models of person, process, product and press in the creativity literature.
- Analyze the purpose and function of select creativity theories and models sufficiently for transfer of learning to other topic areas.
- Identify and apply select creativity constructs, definitions, principles, models and theories to design and plan learning experiences for themselves and others.

Topics

- Basic assumptions regarding values and beliefs about creativity
- Historical perspective of abilities, skills and talent areas related to creative potential
- The foundations of the field of creativity as a multifaceted phenomenon
- Seminal definitions and models that formed creativity studies
- Organizational schemas, frameworks and families of theories
- Designing and delivering learning using creativity models and frameworks

TIM Course Re-Design

Although the goals and topics remained relatively constant, the redesign of the delivery of the course put a larger emphasis on designing the entire experience using the TIM. Starting with Heightening Anticipation even before students met as a group, then Deepening Expectations and Extending the Learning, two creativity skills (Visualize it Richly and Colorfully and Put Your Ideas into Context) were integrated throughout the entire experience. This provided an emphasis on both content (main content and creativity content) and process in the design and delivery of the course. Using this design format increased opportunities for students to continue to think (incubate) and make further connections about the content long after the course was completed. The outline of the student syllabus in Table 4 illustrates this design.

As a way to set the purpose and motivation for the learners and add an element of surprise, a packet of information arrived in the mail five weeks before the start of the course. This packet included activities and information to Heighten their Anticipation in a visually rich way. This was particularly powerful for our many international students who rarely received packages from course instructors, and showed the
degree to which the instructors committed to warming them up visually to the class. When the students came to the seated portion of the class, their anticipation was sufficiently heightened! They engaged deeply in both the content and the selected creativity skills integrated during the seated portion of the class to Deepen Expectations. After the seated portion there were a few additional assignments that assisted them with connecting to the course material in personal and professional ways to keep the learning going.

**SPECIFIC LESSONS**

In this section, the authors will present the outline of three lessons. The original design, the revised version and an alternate lesson featuring a different creativity skill are provided for the individual lessons, all using the TIM framework. For each lesson, one creativity skill was chosen to integrate. Although different lessons may lend themselves to a variety of skills, it was important to pick one and focus on the integration of that one skill as the emphasis to teach effectively for creativity while teaching a content element. So on the micro level of a lesson, the instructor is focusing on the specific content and creativity goal for that lesson while still keeping the bigger course framework (macro level) in mind with regard to

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**Table 4. Outline of CRS 560 distance program syllabus**

<table>
<thead>
<tr>
<th>Syllabus for Foundations of Creative Learning</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>THREADED THROUGHOUT ARE: PUTTING YOUR IDEAS INTO CONTEXT &amp; Visualize it RICHLY and COLORFULLY!</strong></td>
</tr>
<tr>
<td><strong>Heighten Anticipation</strong></td>
</tr>
<tr>
<td><strong>ONLINE</strong></td>
</tr>
<tr>
<td><em>Five Weeks Prior to Seated Course:</em> Warm up to classic theories and models of creativity: Defining creativity for yourself and exploring scholarly perspectives on creativity. Examining foundational thinkers and concepts in the field. Consider your current contexts… personal and professional…. and reflect on the knowledge gained in your pre-work with regard to what it means, what you know, what you desire to continue to learn and how you might apply it in the future.</td>
</tr>
<tr>
<td><strong>SEATED CLASS TIME</strong></td>
</tr>
<tr>
<td><em>Day One:</em> Orienting ourselves to the Second Summer &amp; Beginning CRS 560: Developing a climate that is conducive to creative learning. Introductions (backgrounds, interests, learning goals, etc.), course content and process overview. Putting your personal timeline in the context of the field of creativity.</td>
</tr>
<tr>
<td><em>Day Two:</em> Warming up to Classic Theorists: Examining definitions and building a theoretical base in creativity for your thinking and learning. Playing with a skill base for creativity. Looking at your learning and thinking from a variety of viewpoints and angles.</td>
</tr>
<tr>
<td><strong>Deepen Expectations</strong></td>
</tr>
<tr>
<td><strong>Day Three:</strong> Digging into Creativity Skills and Concepts: Building off a skill base for creativity, examining a model for integrating creativity into content. Deepening our understanding and connections to the history of creativity and major scholars and theories that form the disciplinary framework. Examining your philosophical foundations related to the field of creativity.</td>
</tr>
<tr>
<td><em>Day Four:</em> Foundations for the Field of Creativity: Continuing to dig into the many, varied dimensions of the field of creativity and exploring classic models of creativity that formed the beginning inquiry and practice in the field.</td>
</tr>
<tr>
<td><em>Day Five:</em> Classic Creativity Models: Strengthening our knowledge base with regard to specific classic models, experiencing the Torrance Incubation Model of Teaching and Learning.</td>
</tr>
<tr>
<td><strong>Extend the Learning</strong></td>
</tr>
<tr>
<td><strong>Day Six:</strong> Putting Your Ideas into Context and Looking Forward: Taking the learning forward – from your literature to the literature of creativity, from creativity theories and models to future use, planning for future learning.</td>
</tr>
<tr>
<td><strong>ONLINE</strong> (and in the next class)</td>
</tr>
<tr>
<td><em>Getting Glimpses of the Future… Formulating your final list of resources and engaging in the next class (CRS 635: Creativity and Change Leadership) and beyond to sing in one’s own key: Incubation at work!</em></td>
</tr>
</tbody>
</table>
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overall course goals and overall integration of course creativity skills. In other words, the instructor is practicing creative teaching and learning right along with the students by engaging in creative activities and high-level metacognitive thinking.

LESSON ONE: DEFINITIONS OF CREATIVITY

Original Design

The content goal was to examine categorizations of a wide variety of definitions in the field of creativity. Each student was required to write a one-page document with five definitions of creativity, obtained from reading the research of different creativity scholars. The students discussed their definitions with their classmates. At the end of the class they were required to submit their assignments to their online Blackboard group.

TIM Re-Design

For the TIM re-designed lesson, the same content goal focusing on definitions was used. In addition, the creativity skill Produce and Consider Many Alternatives was infused into all three stages of the lesson and a goal that focused on the skill was added to the lesson (see Table 5 for the lesson).

As a result of having a month prior to the seated portion of the class, students had an opportunity in the Heighten Anticipation stage to search more widely for definitions that had meaning for them either personally or professionally. The creativity skill Produce and Consider Many Alternatives was included in the instructions to encourage a wide search of various definitions before settling on a few to put on the Post-its. The purpose and motivation for engaging in this activity was set with a video posted on Blackboard for the students to watch. By the time the students interacted with each other in the seated portion of the class, they were ready to deeply engage in the content of examining definitions and to

Table 5. CRS 560 course

<table>
<thead>
<tr>
<th>Definitions of Creativity Lesson</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Content Goal:</strong></td>
</tr>
<tr>
<td><strong>Creativity Goal:</strong></td>
</tr>
<tr>
<td><strong>Heightening Anticipation</strong></td>
</tr>
<tr>
<td><strong>Deepening Expectations</strong></td>
</tr>
<tr>
<td><strong>Extending the Learning</strong></td>
</tr>
</tbody>
</table>
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further practice the creativity skill of Producing and Considering Many Alternatives to improve their flexible thinking. Throughout the week, they continued to visually post more definitions that appealed to them and to capture them electronically for future use as part of the Extending the Learning for this lesson. The collection of definitions produced included scholarly citations and was highly relevant to future classes and course activities. This continued to extend their learning in meaningful ways.

Alternatively, if we had used a different skill, the lesson would have looked much different. See Table 6 for an alternative design using the same content but the skill Combine and Synthesize.

LESSON TWO: CLASSIC SCHOLARS IN THE FIELD OF CREATIVITY

Original Design

The content goal was to analyze the contributions of classic scholars of creativity. Faculty members would provide a traditional lecture-based class with a question/answer delivery of classic scholars in the field of creativity that featured a PowerPoint with descriptions of scholars’ accomplishments.

TIM Re-Design

For the TIM re-designed lesson, the same content goal focusing on scholars was used. In addition, the creativity skill Visualize it Richly and Colorfully was added to the lesson and a creativity goal formulated for the skills. See Table 7 for the lesson which includes a photo of the scholar timeline on the classroom wall (see Figure 2.).

Because of the design of the six-day intensive cohort format, this lesson also took advantage of the time prior to the seated class to heighten the students’ expectations and get them ready to engage deeply in class through their research of a classic scholar. The typical response when students come into the seated portion of the class is one of great excitement and enthusiasm for sharing their scholars. Rather

Table 6. Alternative design- creativity skill: Combine and synthesize

<table>
<thead>
<tr>
<th>Definitions of Creativity Lesson</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Content Goal:</strong> To examine categorizations of a wide variety of definitions in the field of creativity.</td>
</tr>
<tr>
<td><strong>Creativity Goal:</strong> To combine and synthesize different definitions of creativity.</td>
</tr>
</tbody>
</table>

**Heightening Anticipation**
Prior to class, students are asked to collect five different definitions of creativity. As students start the lesson, they are asked to write down one of their favorite foods on Post-it notes, one food per note. Next, the faculty member informs them there will be a game where you have to meet someone and combine your favorite foods (pizza + ice cream) to create a new type of food (pizza flavored ice cream). This game warms the class up on how to combine and synthesize their ideas.

**Deepening Expectations**
Students work in small groups and share the creativity definitions that they collected. Then, each student combines his list into one, comprehensive, new definition of creativity. Next, everyone in the small group has to put their definitions together to create yet another definition, that is shared with the class. Finally, the class comes up with one definition to synthesize all of the definitions.

**Extending the Learning**
The class definition is posted on the door, and is referred to through the rest of the semester. As new learning arise throughout the course, the definition is modified.
than a long overview of scholars’ accomplishments by each student during the seated portion to deepen expectations, the authors gave their students multiple ways of sharing the information visually, time to converse about the scholars in pairs and small groups and the opportunity for each person to highlight the essence of his or her scholar in a five- to ten-minute presentation. The combination of these many options provided a meaningful format for digging deeper. Students also had the opportunity later on in the week to engage “as their scholar” in a scholar party, allowing for a more natural flow of dialog between various participants such as one would see at an informal meeting or conference gathering. To extend the learning, the information was all captured electronically so that the students could continue to refer back to it throughout their creativity studies. This was particularly relevant as most, and sometimes all, of the students in the certificate program enroll in the Master’s of Science in Creativity program when they are done with their 18 credit hour certificate.

Table 7. CRS 560 course

<table>
<thead>
<tr>
<th>Table 7. CRS 560 course</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Content Goal:</strong> To analyze the contributions of classic scholars of creativity.</td>
</tr>
<tr>
<td><strong>Creativity Goal:</strong> To visualize the life and major contributions of classic scholars richly and colorfully.</td>
</tr>
<tr>
<td><strong>Heightening Anticipation</strong> Students selected one classic scholar from the list. Professors sent a packet of information to all of the students’ mailing addresses. Packets contained different colored sheets that each represented a specific decade. Each student had to research his/her selected scholar, and then create a timeline on the colored sheets provided. Students brought timelines to first day of class. Upon arrival, they saw a large piece of white flipchart paper that covered an entire wall of the classroom and was labeled by decade.</td>
</tr>
<tr>
<td><strong>Deepening Expectations</strong> At the start of class, students used pastels to draw in pictures, symbols and words on the white flipchart that represented each decade. Next, students each did a five- to ten-minute visual presentation that showcased the scholar’s life. They added their scholar timelines to the big white wall in the designated category (see Figure 2.). This created a visual, color-coded timeline that spanned the entire classroom.</td>
</tr>
<tr>
<td><strong>Extending the Learning</strong> Students posted individual timelines to Tiki-Toki (<a href="http://www.tiki-toki.com/">http://www.tiki-toki.com/</a>), a website for creating beautiful timelines, so they could reference the various scholars and contributions at a later date.</td>
</tr>
</tbody>
</table>

Figure 2. Scholar timeline wall
Again, while this worked well for the authors, it is not the only way it could have been done. Table 8 presents an alterative design to classic scholars in the field of creativity using the skill, Enjoy and Use Fantasy.

**LESSON THREE: DIMENSIONS OF THE CREATIVE ENVIRONMENT**

**Original Design**

The content goal was to examine the ten dimensions of a creative environment, and to apply those dimensions to a current work environment. The lesson featured a PowerPoint and handout of Ekvall’s (1987) ten dimensions of the creative environment. This was a typical lesson, where students would take notes and ask questions.

**TIM Re-Design**

For the TIM re-designed lesson, the same content goal focusing on dimensions of a creative climate was used. In addition, the creativity skill Look at it Another Way was added to the lesson and a goal was formulated for that skill (see Table 9 for the lesson).

This lesson also provided a model for students to see the TIM as a delivery system in action. Once the debrief of the content (creative environment) was completed, a discussion of the process (the TIM) in which they engaged occurred. Students were introduced to the elements of the TIM, in particular the three stages of Heightening Anticipation, Deepening Expectations and Extending the Learning, as well as the creativity skill of Look at it Another Way. They debriefed each element of the lesson and considered how it encouraged engagement and deep learning. They were given the lesson plan and further discussed the elements they experienced as a delivery system for both content and a creativity skill.

The students already knew they were going to use the TIM to design and deliver a team presentation on a classic model of creativity later in the week. Connections were therefore made as to how they were

**Table 8. Alternative design- creativity skill enjoy and use fantasy**

<table>
<thead>
<tr>
<th>Classic Scholars in the field of Creativity Lesson</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Content Goal:</strong> To analyze the contributions of classic scholars of creativity.</td>
</tr>
<tr>
<td><strong>Creativity Goal:</strong> To explore the life and major contributions of classic scholars through fantasy and imagining.</td>
</tr>
<tr>
<td><strong>Heightening Anticipation</strong> Prior to class, students are asked to “adopt” a scholar, and prepare a five minute presentation as if they are their scholars. When students walk into the classroom, there are costume pieces on the tables and the walls.</td>
</tr>
<tr>
<td><strong>Deepening Expectations</strong> The faculty member hosts an in-class scholar “party” where each student comes into the room as his/her scholar, and interacts with the other scholars as they feel appropriate. For example, the student portraying Sigmund Freud and the student portraying Carl Jung may pretend as if they are in an argument about the role of the unconscious. Following the party, there is an extensive debrief on how the scholars interacted with one another.</td>
</tr>
<tr>
<td><strong>Extending the Learning</strong> Students write a letter to their scholars, sharing what they have learned. They give these letters to the faculty member, who returns the letters to the students at the end of the semester.</td>
</tr>
</tbody>
</table>
Integrating Creative Thinking Skills into the Higher Education Classroom

Table 9. CRS 560

<table>
<thead>
<tr>
<th>Dimensions of the Creative Environment</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Content Goal:</strong></td>
</tr>
<tr>
<td>To examine the ten dimensions of a creative environment, and apply those dimensions to their current work environment.</td>
</tr>
<tr>
<td><strong>Creativity Goal:</strong></td>
</tr>
<tr>
<td>To look at the psychological environment in other ways.</td>
</tr>
</tbody>
</table>

**Heightening Anticipation**
When students entered the room, there were kaleidoscopes and magnifying glasses on the table to engage them in looking at things in the room in multiple ways. They examined definitions of climate, environment, and culture to set the purpose.

**Deepening Expectations**
Students were asked to think of their most creative work environment and list all of the characteristics of that environment. Then, they were asked to think of the least creative work environment they had been in and write down all of the characteristics of that environment. There was a debrief of their experiences.

Next, the authors presented a PowerPoint of the ten dimensions. Students were asked to think about their own responses in relation to the work of Ekvall. They examined negative and positive environments and considered those in their environment who might have different experiences than the students.

**Extending the Learning**
Finally, students went back to the original list from the negative environment and thought about what they could have done differently to make it a more creative environment. The lesson concluded with a debrief of the whole experience.

Table 10. Alternative design using creativity skill: Put ideas into context

<table>
<thead>
<tr>
<th>Dimensions of the Creative Environment</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Content Goal:</strong></td>
</tr>
<tr>
<td>To examine the ten dimensions of a creative environment, and apply those dimensions to their current work environment.</td>
</tr>
<tr>
<td><strong>Creativity Goal:</strong></td>
</tr>
<tr>
<td>To contextualize the psychological environment for better understanding.</td>
</tr>
</tbody>
</table>

**Heightening Anticipation**
At the start of the lesson, students are asked to think about an environment they felt was highly creative and to write down all of the physical and psychological characteristics of that environment. Students share their characteristics in small groups and write them on a flipchart.

**Deepening Expectations**
The faculty member takes the group through a PowerPoint on the ten dimensions of creative environment and for each dimension, asks the group if they have any examples of high or low levels of that specific dimension. For example, one student might say her job working at the coffee shop had a high level of dynamism, and this was demonstrated by the amount of laughter and excitement she experienced throughout the day.

**Extending the Learning**
The faculty member gives everyone a laminated card with the ten dimensions and asks them to post the cards on their bathroom mirrors. This will allow students to reflect each day on how they might make their environments more creative on a daily basis.

But Does TIM Work?

Each class is unique, and the true purpose of a lesson plan is to keep hubris in check by providing an indication of how far one deviated from the path on any particular occasion. So, rather than attempt to...
convince the readers that the authors have solid data to prove that this method produces a better outcome, the authors will instead confess that they don’t know - yet!

On the face of it, this admission may seem unreasonable. Given a large enough class size, and sufficient replication studies, it should be possible to evaluate whether one lesson design is better than another. However, that view is based upon a simpler model of learning: one in which the students could demonstrate whether they have learned the capital of Syria, or the algorithm for a Fast Fourier Transform. The TIM is designed to pursue a slipperier goal: increasing the creative skills of students and set the stage for greater incubation. And, above all else, the authors know that developing these skills takes time, certainly weeks, and probably months (see the Creative Studies Project results in Parnes & Noller, 1973 and observational/descriptive TIM studies in Murdock & Keller-Mathers, 2008). Removing the confounding variables from a research project involving different students, lecturers and contexts over many months makes the whole endeavor highly problematic. And, of course, this is no excuse for avoiding the challenge. In fact, the authors and their colleagues are currently engaged in developing a research study which will contribute to answering the question, but they recognize that this is likely to be a long-term project. Additionally, over the last twenty years, a community of users who have adopted the model, also known as “TIMmers,” continue to work on the development and practice of the model.

So does this mean that, in the meantime, the authors and readers of this chapter are left to simply guess at the TIM’s impact? The authors don’t think so.

One of the great joys of working with graduate students is that they have an educational history. They have been taught by different types of teachers, experienced different lesson designs, and have had the chance to form an opinion as to what works for them. Because of this history, the authors regard the feedback from their students as being a particularly valuable source of insight. Obviously, it is not without its limitations. Even though the feedback is solicited anonymously, all sorts of biases will be at play. But these limitations don’t completely negate the value of the feedback. What really counts is what the students do with the knowledge they gain and, perhaps more importantly, how many of them subsequently adopt the TIM in their own work.

The responses - shown below - are all from recent students in the Creative Studies graduate program. All of the students would be regarded as adult learners, and each of them has been exposed to a range of learning designs throughout the course of their educational careers.

One last comment about the student feedback: it is all overwhelming positive. The authors haven’t omitted commentary that is negative. These examples are representative of the overall feedback.

**Feedback on Course**

- “Studying the TIM was a truly eye-opening experience offering incredible possibilities for engaging students and enhancing the learning experience. As an educator, I’m shocked that more professionals are unaware of the power of this process and do not subscribe to its principles.”
- “The TIM is something I use frequently when I teach now. I feel like knowledge was ‘placed’ in my head this semester. I didn’t have to tirelessly work for it because I loved it!”
- “It was amazing to be immersed in the TIM as we learned it!”
- “A lot of learning happened without us even realizing it!”
- “I loved the way the room evolved!”
- “Peak curiosity about models and theories!”
- “Deepened aspiration to learn more!”
“I didn’t expect the focus on delivery of TIM. That was phenomenal - it blew me away!”

“Being a participant in a TIM lesson brought me back to my days of being a young child where my curiosity was peaked from the start and I was given the freedom to explore, discover and create by actively participating in my learning. The best way I can describe the experience is full engagement... and wanting to learn more.”

“Experiencing a TIM lesson allowed me to apply my learning in a practical sense that is relevant to me... while practicing a creativity skill. It was brilliant!”

“In the ‘deepening expectations’ stage of the lesson I experienced a mix of enthusiasm and questioning. Enthusiasm for digging deeper into the content and learning of the lesson and questioning what needs to happen to reach the next level of learning. A well prepared session such as the one I experienced provided a classroom environment where thinking was encouraged and connections made were not only welcomed but celebrated.”

Lastly, from an email sent directly to the instructors from an international student who is a veteran university professor, this student stated: “Quite frankly, it was certainly the best higher/executive education course I ever attended as a learner. With a great variety of learning techniques, you really made the learning stick in a very theoretical subject. I left with the feeling that we had a real and deep conversation with all of these great minds that founded the field of creativity studies! Thank you for all the energy and professionalism you put in creating this unbeatable learning experience!”

**CONCLUSION**

Although it would be wonderful to provide a nicely packaged conclusion that clearly established the way forward, the authors are not in a position to offer that. Instead the reader is invited to be part of the creative teaching and learning experimental community.

**What is Known**

1. Creative thinking can be developed through various forms of education (see the Creative Studies Project, Parnes & Noller, 1973).
2. It takes time to develop these skills (Puccio, Firestien, Coyle & Masucci, 2006)
3. Using the TIM allows faculty to deliberately design creative skill building activities into every class, without sacrificing the focus on content.
4. Students participating in TIM’d classes consciously or unconsciously practice and develop their creativity skills. Therefore, the more classes designed in this manner, the more practice the students will have had, and - potentially - the more developed their skills will become.
5. Students enjoy the classes the authors have redesigned with the TIM. Furthermore, for many of them, the learning appears to stay with them for significant periods of time.

So at the very least, the authors think it is reasonable to conclude that using the TIM to redesign ones classes is likely to produce enjoyable learning events that stay with students for long periods of time. Furthermore, if educators accept the challenge of enhancing their students’ creative skills, deliberately
building practice opportunities into every lesson will be incredibly beneficial. As International Center for Studies in Creativity alumna Nitkowski (2004) articulated it so eloquently:

*It is my contention that, by exploiting the strengths of this learning and teaching model, teachers can harness any and all of the strategies and best practices in their command, as well as stretch beyond the constraints of more and better of the same approaches and solutions, taking deliberate and exciting steps toward great teaching.* (p. 59)

In the future, the authors will continue to collect anecdotal evidence and other data to demonstrate the TIM’s impact. And until then, they will continue to use the model, partly because it seems to work, and also because designing and teaching TIM’d classes is simply more engaging, meaningful, and fun for both the educator and students.

**REFERENCES**


Integrating Creative Thinking Skills into the Higher Education Classroom


KEY TERMS AND DEFINITIONS

Creative Learning: The act of learning that goes beyond the ordinary to produce original thoughts and useful actions and outcomes. It is deeply connected to the ability to think in original ways, monitor one’s thinking, and utilize natural and/or deliberate creative processes.

Creative Teaching: The act of teaching in a novel and useful way that promotes student growth related to the development of original thought and action. Creative teaching focuses both on the methods a teacher uses to deliver learning and the overall effect those methods have on students and the outcomes produced.

Creative Thinking: Mental activities that lead to original and useful ideas, involving complex cognition and problem solving.

Creativity Skills: Learned abilities related to bringing forward more novel and useful outcomes and/or products, which can be developed deliberately and enhanced through practice, feedback, and diverse applications.

Teaching Creatively: Teaching in a way that provides a highly useful or relevant learning while including an element of novelty in delivery and outcomes. It encourages learners to consider and/or produce in ways they had not done before.

Teaching Creativity: When an instructor is deliberately focusing on creativity as a content outcome in the form of a product, attitude, and/or skill development.

Torrance Incubation Model (TIM): A model originally developed by E. Paul Torrance that provides a framework for the development of lessons consisting of three stages: Heightening Anticipation, Deepening Expectations and Extending the Learning. TIM is designed to provide powerful learning that both promotes the development of creativity by infusing a creativity skill or concept into each stage, and sets the stage for incubation to occur beyond the lesson.
Section 4
PBL and ICT
Chapter 14

Design Thinking in Higher Education: How Students become Dedicated Creative Problem Solvers

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Adam Royalty
Stanford University, USA

Christoph Meinel
University of Potsdam, Germany

ABSTRACT

This chapter introduces design thinking as an educational approach to enhance creative problem-solving skills. It is a problem-based learning paradigm that builds on three pillars: a creative problem solving process, creative workspaces and collaboration in multi-perspective teams. This chapter discusses central elements of design thinking education and contrasts the approach to conventional education as well as other problem-based learning paradigms. In particular, design thinking classes harness a unique “look and feel” and “verve” to help students acquire and experience creative mastery. Furthermore, the chapter overviews empirical studies on design thinking education. Four studies are described in more detail: Experiments on the three pillars of design thinking and one case study where a university class curriculum has been changed to a design thinking paradigm. Finally, the chapter provides resources for readers who want to learn more about design thinking education.
INTRODUCTION

Many countries recognize a need for curricula changes to enhance skills that used to be neglected in school and university education (Noweski et al., 2012; Rasfeld, 2015; Wagner, 2010). One central concern is to help students become dedicated creative problem solvers. In addition, students need to acquire co-operation skills to collaborate in interdisciplinary teams. Many pressing problems today cannot be solved on the basis of specialized knowledge from one single discipline alone.

Design thinking has been identified as a promising approach to help students become creative problem solvers and socially competent team-workers. The approach was pioneered in fields like architecture and mechanical engineering. Originally, it was used to develop innovative products or services that would not only benefit companies financially but also helped to tackle pressing societal problems, like high crime rates or poor health (Brown, 2009; Asquith, Dorst, Kaldor, & Watson, 2013). However, the approach soon turned out to be useful far beyond classical design disciplines. Researchers and practitioners have become interested in design thinking as a means to build up creative confidence, creative agency and creative mastery (Jobst et al., 2012; Kelley & Kelley, 2013; Rauth, Köppen, Jobst, & Meinel, 2010; Royalty, Oishi, & Roth, 2012, 2014). An increasing number of universities opened up design thinking institutes to help students acquire creative problem-solving and collaboration skills that are hardly encouraged by traditional schooling. Great numbers of applicants indicate a substantial interest of students in such unconventional trainings. The quick expansion of the Hasso Plattner Institut (HPI) School of Design Thinking at the University of Potsdam in Germany is a good example. It started off in 2007 with 40 students from 30 different disciplines. Due to strongly increasing numbers of applicants from all around the globe, in 2015 the institute trains 120 students per semester, who currently stem from 20 different nations and have been trained in 70 different disciplines. Students dedicate 2 days of the week to their design thinking training, either for one semester or for a whole year. At the same time they continue their conventional university education on the remaining 3 days of the week.

Regularly, in design thinking classes, students seem to develop a passion for their work that is rarely observable in conventional schooling. Many students quickly develop autonomy and even creative mastery in solving problems. At the same time, design thinking classes teach few things explicitly. Rather, the classes use and teach a work culture of joy, collaboration, action, wild experimentation and rapid learning out in the field. Design thinking impacts the mindset of students more than building explicit knowledge.

This chapter provides a short introduction to design thinking education. The first part introduces design thinking as one approach to problem-based learning, which has quite unique features. The second part discusses empirical studies that investigate the mechanisms and effects of design thinking education, focusing in particular on the development of creative problem solving skills among students. The third part provides resources for readers who wish to learn more about the subject.

FUNDAMENTALS OF DESIGN THINKING EDUCATION

Design thinking is an example of what the community calls “problem-based learning” (Barrows, 1996; Carleton & Leifer, 2009; Schmidt, 1983). Students work in teams on open-ended problems. They decide quite autonomously how to move their projects forwards. Formal lectures are rare and short. Teachers do not claim “authority of knowledge” (Zhou & Valero, 2016, p. 134). Rather, they act as facilitators.
At the same time, the approach is unique in several regards. In design thinking projects, students work on “design challenges” provided by serious project partners. In the past, global companies or non-profit organizations like SAP, JetBlue, Fraport, Volkswagen, Siemens, Special Olympics or Germany’s Federal Ministry of Education and Research have been project partners in design thinking education. Typically, a team of 3 to 6 students works on each challenge. They can be asked to “redesign security processes at airports”, to “help mentally challenged persons move autonomously in a city” or, very generally, to “redesign workplace experiences”. At first, design thinking teams create their own unique outlook on the challenge and identify the precise problem they want to tackle. Later on, they head for a thrilling, creative solution.

Design thinking work culture builds upon three pillars. They are called the “3 Ps”, standing for process, place and people (HPI School of Design Thinking, 2015).

**Process:** Among the few things that design thinking students learn explicitly, a process of creative problem solving plays a prominent role. The process exists in several versions. A current one reads: (1) Empathize, (2) Define View, (3) Ideate, (4) Test Prototypes, (5) Bring Home. In each phase, the team can choose among many methods that have been adapted from different disciplines.

**Place:** To support creative team-work, design thinking locations are carefully designed. The space is variable and can be adapted to the needs of each project. Tables, couches and shelves are placed on wheels, such that they can be moved around easily (Figure 1). Walls and many other surfaces are used to visualize thoughts. Craft material helps teams create tangible, sometimes “toy-like” prototypes.

**People:** Design thinking embraces a culture of “radical collaboration” and of “collaboration at eye-level”. Design thinkers work in teams. Multidisciplinarity is very welcome, both in student teams and the teaching staff. Hierarchical differences are evened out as much as possible. Teachers act as facilitators; they help students reflect on their work process by spotting difficulties or opportunities and by providing new impulses when energy is wavering.

To convey an idea of a design thinking project, the task of redesigning airport security processes shall serve as an example. Given this challenge, a design thinking team will first try to **empathize** with

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*Figure 1. A creative space at the HPI Potsdam. Tables and couches are placed on wheels. The small number of volumes in the “D-Library” suggests that books are there to inspire. They do not compile the whole knowledge of the world that is worth knowing. Students are supposed to go out and learn about the world first-hand, not by reading books.*
Design Thinking in Higher Education

people who are involved. The team can use methods such as interviews, behaviour observations, video documentation or personal experiences to understand the needs of different stakeholders. When defining a point of view, the team might decide to focus on passengers – not on police officers, cleaners, pilots or other people affected by airport security processes. The team will also identify a need. Maybe they note that passengers would prefer to sit down while waiting for the security check. Furthermore, a striking discrepancy can yield an insight to build on: at first, passengers spend a lot of time waiting, doing nothing. However, once they have reached the security check, from one moment to the next they hectically engage in action, sorting electronic equipment, liquids and other belongings into different baskets. In the phase of ideation, the design thinking team will try to come up with as many different ideas as possible to solve the identified problem. They will pick one or two options and test prototypes with real users. For instance, the team can design a “security trolley” shaped like a chair on wheels. The trolley has multiple compartments such that passengers can sort their different belongings into boxes already while waiting in the line. Once done, passengers can sit on their trolley and wait for the security check in a comfortable position. Finally, in the Bring Home phase, the idea is passed over to someone who can make it real, someone who can build security trolleys for airports. (This example is based on a design thinking project at the D-School in Potsdam.)

Next to the 3 Ps—Process, Place and People—design thinking education is characterized by other features that seem particularly important for its positive outcomes.

Safety: Design thinking is taught and practiced in safe environments (d.school, 2012a). That means, first, students can move around freely and concentrate on work tasks without having to worry that someone might steal their jackets, backpacks or electronic devices. Second, coaches and teachers ensure that their courses are safe places for students to experiment, to try wild ideas and in particular safe places to fail. Students are invited to try 100 very diverse ideas, see 99 fail, derive important new insights and filter down to one outrageously good idea.

Verve: Design thinking is an energizing and often joyful process, or mode of working. Coaches and teachers pay close attention to the energy level and mood of students. Warm up games or “improv activities” (d.school, 2014) help create the specific mood that is considered helpful in each stage of the process. Often times, music plays in the background. Different music samples have been compiled for different stages of the process (d.school, 2012b), once again stimulating specific moods. Time constraints are used as a productive stressor to forestall unconstructive discussions and get people going. Furthermore, the architecture (Doorley & Witthoft, 2012), the equipment (d.school, 2011) and model behaviours of experienced design thinkers (d.school, 2012a) help create a playful and joyful atmosphere. The intent is not simply to make people feel good. Positive affect has been shown to positively correlate with creativity (Amabile et al., 2005). Cultivating fun, not fear is a necessary support. Finally, the community celebrates their work process. Often times, there are presentations “on stage” with constructive feedback sessions and applause from the audience.

Sense: The whole setup of design thinking projects lets students experience how important and sensible their work is: they tackle crucial real-life problems, in face-to-face exchanges with affected persons (“users”), on behalf of actual project partners who can make visions real. Furthermore (as in other settings of problem-based learning), students are invited and challenged to find the path that makes most sense to them in handling wicked problems (von Thienen, Meinel, & Nicolai, 2014). There is no predefined problem for teams to work on. Rather, teams explore a diffuse problem domain from different perspectives. They reframe the problem according to team preferences. “Point of
view madlibs” (d.school, 2010a) support the specification of thrilling project directives. Teams also decide for themselves, which ideas they prototype and test, when to move from one process phase to another and how to use the space they work in.

**Culture:** Design thinking is much more than a teaching method. It is a whole culture that promotes specific ways of working, of thinking and of dealing with one another. Already, the architecture and room equipment is a manifestation of design thinking culture. Large panels on the walls convey design thinking mottos and help newcomers arrive at “the world of design thinking”. These panels display inspirational mottos like; “encourage wild ideas”, “defer judgement”, “bias to action”, “embrace experimentation”. Playful prototypes such as Lego models and plenty of craft materials reveal that – as design thinkers – students will work with their hands, are free to play and try things out. Furthermore, design thinkers are generally well connected. Pools of talented people form around design thinking schools; they are united by a design thinking mindset of co-operation despite their diverse professional backgrounds.

**Different “Look and Feel”:** Design thinking classes have a unique look and feel. The setting and atmosphere is unlike that of other university classes. Indeed, the authors of this chapter hold that such a different look and feel is an essential ingredient of design thinking education. After all, design thinking has been developed to yield skills, work practices and cultural values that students fail to develop in traditional education. Therefore, design thinking classes need to communicate that a different manner of working is valued here.

**DIFFERENCES TO OTHER APPROACHES TO PROBLEM-BASED LEARNING AND TO CONVENTIONAL EDUCATION**

This chapter introduces design thinking as an example of problem-based learning. At the same time, design thinking is called “unique”. The authors of this chapter hold that the specific look and feel of design thinking classes is an important distinguishing parameter.

To explain this idea in more analytical terms, a dialogue examined by Mehan (1979, cf. Sinclair & Coulthard, 1975) shall be re-analysed and elaborated. He contrasts two scenarios that help to pinpoint the difference between (1) conventional education, (2) many other approaches to problem-based learning and (3) design thinking.

**Conventional Education:** Here is an example of traditional education. At school, the following dialogue might take place.

Speaker A: What time is it, Denise?
Speaker B: 2:30.
Speaker A: Very good, Denise.

This dialogue illustrates the look and feel of traditional education. It suggests an idle effort on behalf of the student. Her answer does not solve any problem out there in the world, apart from educational purposes. She merely allows the teacher to evaluate her level of knowledge and proficiency.

**Problem-Based Learning:** The following dialogue is very similar and yet conveys a different scenario.

Speaker A: What time is it, Denise?
Speaker B: 2:30.
Speaker A: Thank you, Denise.

This dialogue is more likely to occur outside of school. Denise may have the gratifying experience of helping someone out. Speaker A lacks knowledge (regarding time) that Denise can provide. However, Denise will not credit herself with having said something so remarkable that all experts in the field are stunned, because they never heard such a great answer before.

Many approaches to problem-based learning create a scenario of this second type. In the ideal case, students are not only confronted with fictitious problems, but with real-life persons who introduce real-life challenges. For instance, a patient comes in and reports symptoms. When students successfully produce an adequate diagnosis and treatment, they might be likely to experience task-specific mastery. They solve a real-life problem and hear an honest “thank you” in the end.

**Design Thinking:** In the case of design thinking, problem-based learning is not only used to enhance problem-solving skills, but also to enhance creative skills.

When Denise is asked for the time, and when medical students are asked for a diagnosis in problem-based learning, the task they work on typically does not start a design thinking project. In both cases, no excessively unique solution is requested. Rather, different persons working on the same challenge (e.g., different medical experts) might all come to similar solutions (the same diagnosis).

In design thinking, project partners pose vital, open-ended questions regarding pressing problems of the day that affect many people. “How might we…?” Over weeks or even months students work to provide a thrilling reply. Then, project partners react. Their reaction is used as an unofficial metric for the success of a design thinking project. If project partners react like Speaker A in the dialogue above, saying “thank you”, the project is basically considered a failure. The answer design thinkers work for is a deeply moved “WOW!” (cf. Leifer, 2012, 2013). In a similar vein, Liedtka & Ogilvie (2011) relabel stages of the design thinking process; explicitly, one stage is guided by the headline “what wow’s” (p. 31).

In design thinking education, this is the kind of conversation that is expected over time; and it is often observed in practice.

Speaker A: How might we…?
Speaker B: We could…
Speaker A: WOW!

Such a dialogue suggests the *look and feel* of design thinking. Students experience themselves as contributing something extraordinary, something surprising and thrilling no one has thought of before. By themselves, they have found a solution for a pressing problem out there in the world. Users and project partners embrace this new solution with great excitement. Students can be “flashed” by their own capacity to understand and solve a fundamental problem of the world. When a design thinking project succeeds, students experience creative mastery.
THE LOOK AND FEEL OF CLASSES: CUITNG STUDENTS INTO DIFFERENT SCENARIOS

Why does design thinking have a unique *look and feel* that is so different from traditional education? Next to the specific questions that start a design challenge (“How might we…?”), other factors seem essential too. The architecture is carefully designed to differ from conventional seminar rooms. Furthermore, the design thinking process suggests a scenario where the protagonists are “explorers” or “inventors” rather than “students”, both because of its vocabulary and the scheduled activities.

By contrast, there are other process models in problem-based learning that do enforce quite traditional student roles. For instance, Schmidt (1983) suggests a seven-step process:

**Step 1:** Clarify terms and concepts not readily comprehensible.
**Step 2:** Define the problem.
**Step 3:** Analyse the problem.
**Step 4:** Draw a systematic inventory of the explanations inferred from step 3.
**Step 5:** Formulate learning objectives.
**Step 6:** Collect additional information outside the group.
**Step 7:** Synthesize and test the newly acquired information. (*Schmidt, 1983*, p. 13)

In step five, the term “learning objectives” is immediately reminiscent of a traditional school scenario. Participants are asked to learn something, even though they are allowed to formulate learning goals for themselves. By contrast, in design thinking classes, participants are not prompted to achieve learning goals, but to solve problems. Learning (from empathizing with users, testing prototypes etc.) figures as a highly effective means along the way to achieve great solutions.

Furthermore, a lot of Schmidt’s vocabulary suggests a traditional scientific paradigm. Students work on terms and concepts; they systematize and make inferences. Such a process suggests the *look and feel* of serious science rather than “an epic voyage” and “unexpected discoveries”. The process model of design thinking is very different in that regard: (1) Empathize, (2) Define View, (3) Ideate, (4) Test Prototypes, (5) Bring Home. In design thinking, students empathize; they don’t theorize. Design thinkers turn to people. Schmidt’s students turn to the “dictionary” (*Schmidt, 1983*, p. 13). Then, design thinkers choose a viewpoint. Once again, this task is a cue not for traditional “serious” science but rather for storytelling. For instance, the story of a war can be told from the viewpoint of a king, a poor child, a warrior etc. Schmidt’s students, by contrast, do not choose viewpoints but “hypotheses” (ibid.). Design thinkers ideate wildly, tapping their creativity. Schmidt’s students tap “prior knowledge” (ibid.). Design thinkers build prototypes, which they test with real users. Schmidt’s students consult the “literature” (p. 14) to evaluate and substantiate ideas. This comparison is not meant to suggest that one approach be better than the other. It simply illustrates that the two approaches are reminiscent of quite different scenarios. They have a different *look and feel*. Project work according to Schmidt’s model resembles traditional education much more than design thinking project work.
IMPACT OF DESIGN THINKING EDUCATION ON STUDENTS

Generally, what effects do design thinking classes have on students? First of all, it is a striking observation that students regularly report profound impacts on their whole lives (cf. Plattner, Meinel, & Weinberg, 2009; Meinel, Weinberg, & Krohn, 2015). Students voice severe changes of their self-image, private habits, work-styles and career preferences. Thus, once again there seems to be a sharp contrast to many other classes, which students take and quickly forget about afterwards.

Royalty et al. (2012) explore what learning outcomes alumni attribute to their design thinking training – sometimes years after graduation. The authors report survey findings from alumni (N=175) who graduated between 2005 and 2011 at Stanford University, and results from in-depth follow-up interviews (N=16). They find that “alumni apply a range of design thinking methods and dispositions in their professional lives, particularly related to creative confidence, comfort with risk and failure, and building creative environments” (p. 95). The majority of alumni state they still use what they have learned in their design thinking education on a weekly basis. All alumni attribute some level of confidence in their creative abilities to their time at the d.school, where they learned and practiced design thinking.

Indeed, building up creative confidence has become a central and official goal of design thinking education (Kelley & Kelley, 2013). Someone who does not believe in his or her creative abilities will rarely give them a try. Creative confidence is a major prerequisite for creativity.

Design thinking classes seem quite successful in fostering creative confidence. A design thinking teacher reports in a qualitative interview: “If I ask students at the beginning of a term: Who of you is creative? Almost nobody raises his/her hand, except some design or art students. When I ask them at the end of the first year, almost everybody says: I’m!” (Rauth et al., 2010).

Royalty and Roth (2016) analyse the effect of design thinking education on creative confidence with a quantitative approach. They compare three groups of students: (1) Students who take a design thinking class (N=31), (2) students who apply for the design thinking class but are not enrolled (N=51) and students who take a product design class at Stanford University that also addresses issues of creativity and innovation, but uses a more traditional educational model (N=31). All students answer questionnaires before the classes start and after they end. The authors find that only design thinking affects creative confidence positively. In both control conditions, the student’s creative confidence does not change significantly over time.

Another focus of research has been to illuminate neuro-cognitive effects of design thinking education. Bott et al. (2014) report that design thinking training enhances goal-directed attention and information processing. Saggar et al. (2015) find high performance in a creativity task to be correlated with an increased activity of the cerebellum. This is surprising, given that the cerebellum is traditionally thought to facilitate bodily movements and not (creative) thinking. By contrast, an increased activity of the prefrontal cortex – traditionally associated with conscious thinking – does not predict good creative performance. Quite to the contrary, the prefrontal cortex is active when subjects find a creativity task difficult and don’t perform so well. In sum, the authors suggest that conscious monitoring and volitional control might actually be adverse to creativity. As Saggar puts it: “The more you think about it, the more you mess it up” (Stanford Medicine, 2015).

The findings of neuro-cognitive studies seem to support a general philosophy of design thinking: Bias to action. Don’t discuss, judge and make plans upfront. Try things out immediately, learn and iterate quickly. Dow and Klemmer (2011) test this strategy in a behaviour experiment and contribute further evidence for its effectiveness. Participants (N=28) are asked to build a vessel from everyday materials...
in 25 minutes. The vessel shall protect a raw egg from crushing while it is dropped from increasing heights. Task performance is measured in terms of the highest height at which an egg survives the fall. In the experimental condition, participants receive a full carton of eggs. They are encouraged to test their vessel prototypes at minutes 5, 10, 15 and 25. Participants of the control condition only receive one egg altogether. In the end, the average drop height that eggs survive is almost twice as high in the experimental condition as it is in the control condition. Thus, biasing to action and iterating designs seems a very successful strategy. At the same time, the authors report interview findings that illuminate challenges of design thinking education. Several participants from the experimental condition say they felt uncomfortable “having to iterate too early and too frequently” (p. 125). After all, a vessel prototype at minute five is likely to be unfinished and there was little time to think it through. Thus, it seems all the more important that design thinking classes do not only teach a successful work strategy. There needs to be a safe environment and a cheerleading community to help students test “unfinished work”, see it tank and learn from “failures”.

The overall package of design thinking education at the d.schools in Stanford or Potsdam seems quite effective in that regard. Energetically, students embrace a work routine even though it often requires them to abandon their “comfort zones”. Plattner (2009) uses an unconventional metric to assess this effect. As he describes the start of Potsdam’s D-School he notes:

Already after a short period of time people had so much fun that we almost had troubles paying the electricity bill because the light would never go out at the HPI School of Design Thinking. I was there several times in the evenings; there was light in the workrooms! What do they do there? They work at night. It’s so much fun to sit on a red couch and work on the solution of a problem. (Plattner, 2009, p. 21, authors’ translation)

In what follows, empirical tests of design thinking education shall be discussed in more detail. Special attention is paid to the three “pillars” of design thinking: Process, place and people. In a fourth section, a case study is described where an existing course curriculum has been changed to incorporate design thinking elements.

**How Students Become Happy Problem Solvers: A High-School Experiment on Different Teaching Approaches**

Noweski et al. (2012) test the effects of design thinking education in an experiment with 116 high school students. The study takes place on 3 subsequent days in a German Gymnasium with all students of the tenth grade (four classes of students; participants aged 15 and 16).

Students are randomly assigned to the experimental or control condition, yet making sure that gender and classes are dispersed as equally as possible. In many respects, the experimental and the control condition are designed to be alike:

**Problem-Based Learning, Teamwork, Project-Based Learning:** Students work in teams of 4 or 5 members. They work on a project, or more precisely a design challenge. This challenge is identical for all teams: Come up with ideas how teachers could profit from the students’ knowledge of digital media.
Teachers in the Role of Coaches: Twelve teachers accompany the students. Each teacher supports two student teams. There is little formal lecturing. Teachers rather help the students find their own paths as they tackle the challenges.

Design Thinking Work Spaces: All students receive the same equipment, which is typical of design thinking work. Each team has two moveable whiteboards, sticky notes, pens etc., a movable high table and highchairs. Thus, “standing” is inevitable for most of the time.

However, the experimental and the control condition also differ in crucial respects:

Experimental Condition: Design Thinking: Six of the teachers are trained design thinkers. They teach their teams a design thinking process to tackle the challenge, including specific methods for each process phase. Furthermore, these teachers are trained to monitor the students’ mood and energy level. Typical design thinking interventions are launched to help the students have fun, find a thrilling problem statement and explore many possible solutions including wild ideas.

Control Condition: Dewey-Kilpatrick Approach: Six of the teachers use an educational approach suggested by Dewey (1916, 1931/1935) and Kilpatrick (1918). This approach is explained in a more philosophical and abstract fashion by the authors. There is no clear process model. However, teachers are supposed to play a similar role as in design thinking, facilitating the students’ journey rather than dictating what was “right” or “wrong”. The teachers also help the students find their own path, e.g., by letting them note down a plan before engaging in action.

While students like to work on the design challenge in both conditions, design thinking consistently yields more positive results than the Dewey-Kilpatrick approach.

- **Design thinking has more positive effects on the students’ social skills.** All students fill out the Social Competencies Inventory ISK (Kanning, 2009) before and after the project days. In 18 out of 21 scales, students of the design thinking condition obtain higher gain scores.
- **Students rate the coach-team relationship more positively in the design thinking condition.** While teachers in both conditions are received well, design thinking teachers consistently obtain better ratings on all scales. They are described as more benevolent; the relationship is rated as more relaxed, trustful and co-operative.
- **Students appreciate the design thinking methodology more than the Dewey-Kilpatrick approach.** While “the method used throughout the last days” is rated positively in both study conditions, design thinking – once again – receives better ratings on all scales. Students like this methodology better; they find it more practical, more effective, more fun and they are more eager to use it again.
- **All teachers believe design thinking has better effects on students.** Teachers believe “the youth” would profit both if Dewey or if design thinking projects were launched regularly at schools. However, positive effects attributed to design thinking are much larger. Students are expected to be much more motivated, engaged, independent, determined, productive, reflected and socially competent if there were more design thinking projects at schools.
- **Teachers prefer to use the design thinking approach.** All teachers would like to use the design thinking methodology at school if they had the chance. By contrast, teachers are uncertain whether they would choose to launch a Dewey/Kilpatrick project by themselves.
Both students and teachers have positive sentiments all the time. However, design thinking teachers feel better than Dewey teachers in the end. On all workshop days students and teachers specify their mood on a scale from -10 (extremely negative) to +10 (extremely positive). Mood is assessed each morning, midday and in the afternoon. Both for teachers and students, on each point of measurement and in both study conditions the average mood is positive. However, at the end of the workshop, when all teams have presented their final ideas, the mood of Dewey teachers drops to an “all-time low”. By contrast, the mood of design thinking teachers reaches an “all-time high”.

This experiment with high school students investigates one of three design thinking pillars: a specific work process. Obviously, the process is quite favourable. It yields additional benefits compared to a similar teaching approach, which also embraces problem-based learning and project-oriented teamwork.

Next to the process, design thinking rests on two other pillars: place and people. The second pillar has been tested in the following study.

How Students Become Creative Problem Solvers, Even Against Their Own Will: A University Experiment on Different Learning Environments

Design thinking is taught in unique work spaces—rooms or buildings—that are designed to foster target-oriented and team-based creativity.

Stimulating Creativity: Design thinking locations include a variety of equipment which induces a mood of playfulness and experimentation. Many objects in design thinking spaces can also be found in Kindergarten. There are craft materials including colourful pens, paper, scissors and glue, Lego blocks, polystyrene beads and the like. There are even cosy corners to relax. At the same time, the equipment does not pre-determine any specific usage. For instance, there are no ready-made dollhouses that would call for playing “doll at home”.

Target-Oriented Work: Design thinking equipment is very flexible. Both the prototyping-material and the overall room-setup can be used in multiple ways, creating different moods and opportunities. For instance, whiteboards on wheels can be used to create tiny team-corners where student teams work in some kind of privacy. When whiteboards are moved aside, there is a wide open space for presentations in front of large audiences. Music and light is also used to create different work settings (d.school, 2012a; Doorley & Witthoft, 2012). Thus, students and teachers automatically reflect on their next purposes and set up the space accordingly.

Fostering Teamwork: While design thinking spaces are very flexible, they do not support all possible modes of working. There are design thinking “anti-spaces”: Locations or settings which make it particularly difficult to practice design thinking. In a study with design thinking experts from the d.school at Stanford and the D-School of Potsdam (von Thienen, Noweski, Rauth, Meinel, & Lang, 2012), the following places were named as TOP 3 design thinking anti-spaces: (1) a prison, (2) a conventional classroom/office/cubicle and (3) a library. All of them tend to isolate people, for instance, by promoting single-person quiet desk work. In terms of the architecture and room equipment, design thinking spaces carefully avoid the look and feel of such anti-spaces. Even if one tries, it is very difficult to find zones for concentrated one-person quiet desk work in design thinking architecture. Rather, it promotes the noise and jumble of creative teamwork.
What effects does it have when the same class is taught in different places? In a study with 16 university students (von Thienen et al., 2012), the effects of places are investigated experimentally. All students come together for a 2-day workshop to study measurement and test theory of the social sciences. At first, the participants listen to an introductory lecture on the subject. Afterwards, they receive reading material and a challenge to work on. They shall help a 16 year old girl named Anna who wants to find out (measure) how she comes across in different outfits. What suits her best, what doesn’t suit her at all? Among the reading material of study participants, there are also step-by-step guides to construct measurement instruments according to several standard approaches of the social sciences. On a random basis, students are grouped into teams and sent to different work environments. Half of the students work at the d.school, the other students work in a conventional seminar room located in the same building at a different floor. After two days, all students come together again to present their approaches and results.

The participants come to the workshop to practice for exams on standard methodological procedures. Participants do not expect to be creative during the workshop. However, there is a twist in the study design. In reality, none of the step-by-step guides that is made available to the participants helps to answer Anna’s question straightforwardly. All methodological procedures described in the reading material need a major adaptation to yield sensible answers in Anna’s case.

At both locations, students do not notice the discrepancy between their step-by-step guides and the challenge they work on. Teams simply pick one step-by-step guide and want to follow it strictly. In the conventional seminar room, the workshop participants actually proceed that way. Thus, they calculate sense-less numbers which cannot answer Anna’s question. However, the students obviously do not notice any pitfall, not even during the final presentation on the second workshop day when they report to the audience what they did and found out.

At the d.school, students have the same intention to follow one step-by-step guide strictly. However, without noticing it, they fundamentally change the approach described in their reading material. This unnotice adaptation actually allows them to calculate sensible numbers that answer Anna’s question. Only after more than one day, students at the d.school notice that there seems something wrong with their calculation. Once they become aware of the methodological changes they made on their own, they are very surprised and discuss how to move on. They decide to proceed with their newly created measurement routine first, to answer Anna’s question. Afterwards, they formulate another question for Anna, which allows them to apply a standard approach of measurement and test theory in a sensible way.

Thus, even against their own will, students at the d.school are creative. They devise a new measurement routine which allows them to answer the question they work on. This creativity is actually accompanied by making good use of the d.school space. Students move around furniture to account for differing needs over time. As a matter of their free and spontaneous choice, they also use perukes and other prototyping material to act out the challenge. One student dresses up like Anna in different outfits (see Figure 2). Another student takes pictures, which are then printed out. The students assign themselves different roles (grandmother, best friend, father etc.). Everyone looks at the pictures and numerically evaluates how they like each look. Thus, students at the d.school are “closely in touch with Anna” throughout the challenge.

Students in the conventional classroom also have cameras at their disposal. However, they do not decide to act out Anna’s challenge in concrete terms. They rather focus on the reading material as primary equipment over the days. Thus, there are also some hints as to why students at the d.school are creative and sense-making, while students in the conventional seminar room replicate standard measurement routines without sense and meaning.
How Students Become Welcoming Collaborative Problem Solvers

Next to the two pillars “process” and “place”, there is a third design thinking pillar that seems to be the most ambivalent in terms of research findings. This pillar is named “people”. It might also be called “radical collaboration” or “plurality of people”. Whenever possible, design thinkers work in teams; and teams are set up to be diverse. To achieve diversity is even one selection criterion when the teaching staff sees applicants at the schools of design thinking.

There are good reasons that speak in favour of team diversity. Each academic discipline provides students with a unique vocabulary, methodology and outlook on the world. Typically, students learn to tackle problems by applying ever the same analytic strategies and standard solutions. However, very often, it is the academic discipline rather than a problem by itself, which suggests unvarying solutions. After all, different academic disciplines promote different analyses and solutions. For instance, when there is a problem situation because a youngster robbed an old man underneath a bridge, a psychologist might focus on the youngster’s mindset while an architect notices bad lighting conditions under the bridge.
that he wants to change. Thus, there is a danger of overlooking potential solutions because problems are immediately interpreted through the lenses of single academic disciplines. To avoid this pitfall, design thinking calls for an extensive exploration of problem and solution space first, before a team decides on one point of view. The final team perspective is supposed to be both thrillingly new and promising. Against this background, different academic trainings seem a resource for teams. Multidisciplinary collaboration could help teams overcome cognitive automatisms, which predetermine how a problem is framed and what kind of solution is considered.

Work reality is another issue that counts in favour of team diversity. Both in the economy as well as in science, increasingly often the specialized knowledge of one discipline does not suffice to tackle issues. Specialists with different professional backgrounds must collaborate to solve problems jointly. However, this can be difficult given the dissimilar vocabulary and methodology that people are used to.

In terms of research findings, however, it is a striking observation that team diversity does not predict better work results. Kress and Schar note: “Existing organizational behaviour research has shown that diversity on a team has mixed and frequently negative effects, particularly when outward indicators such as gender, ethnicity, age and experience measure diversity” (2012, p. 189). In light of this data, Kress and Schar consider the idea that diversity of thinking styles (“cognitive diversity”) might be a better predictor for project success. They study 97 master-level engineering students in eight different countries who collaborate in teams over a period of 8 months. However, in the end the authors find “that overall cognitive diversity does not appear to correlate with overall team project performance” (p. 189).

Similar results are found in an experiment with 40 students who work on a design challenge over a week (von Thienen, Noweski, Meinel & Rauth, 2011). Half of the participants work in mono-disciplinary teams, the other half in multi-disciplinary teams. All teams face the same challenge. Their solutions are rated by four independent experts in the end. Strikingly, the solutions presented by mono-disciplinary teams obtain significantly better ratings than solutions of multidisciplinary-teams.

Next to the effect of team diversity, the experiment just described monitors a second factor. Half of the participants are trained design thinkers; the other participants are novices who have no design thinking experience. Thus, in sum the experiment covers three design thinking mono-disciplinary teams, three design thinking multi-disciplinary teams, three novice mono-disciplinary teams and three novice multi-disciplinary teams. Several measures of the study assess communication problems in the teams. Consistently across all measures and study conditions, trained design thinkers experience less communication problems than novice teams. So, there is some evidence that design thinking education has positive effects on team communication.

Reviewing empirical evidences available up to this day, the authors of this chapter hold that multidisciplinary teams cannot be considered a strategic means to achieve better or more innovative project results yet. Maybe in the future that will be the case. The community still needs to find better techniques to make use of the great potential that should lie in multidisciplinary expertise.

However, design thinking seems to have something valuable to contribute already. Given that multidisciplinary collaboration is a necessity in many economic or scientific projects, design thinking might help to reduce communication problems in mixed teams. Furthermore, there is qualitative evidence that design thinking creates a passion for collaboration that might be all the more important in diverse teams. Given that science regularly observes a “performance deficit” of mixed teams, its members might experience their collaboration as somewhat frustrating. However, unanimously, observers report that design thinking students seem to enjoy multidisciplinary collaboration rather than trip over its hardships. As one design thinking teacher reports: “In my years at the D-School, I never heard students complain that
they rather would like to work in mono-disciplinary teams. Quite to the contrary, they find it inspiring to have diverse teams” (A. Perlich, personal communication, October 12, 2015). Another teacher writes on the same issue: “In general I have seen and experienced teams with difficulties and ups and downs, but never heard anyone blaming it on the [difference of] educational background!” (M. Taheri, personal communication, October 13, 2015). Regarding the diversity of teams she also confirms: “D-schoolers seem to enjoy it” (ibid.). This perceived value extends to alumni. Royalty et al. (2012) find that d.school alumni cite working with cross-disciplinary teams as one of the most salient memories from learning design thinking.

Many of the alumni interviewed in the study report that their d.school course was the only time they worked in diverse teams during their time in school. However, nearly all of the respondents report working in diverse teams following graduation. In this sense, design thinking uniquely prepared them for collaboration in authentic settings.

Design thinking uses many techniques to create a collaboration culture. For instance, the motto “build on the ideas of others” is used deliberately to help teams grow together (cf. von Thienen & Meinel, 2015, for an overview of techniques). Furthermore, the design thinking process might be a supportive factor. Students are told explicitly that they need to explore problems from multiple perspectives. Different academic backgrounds figure as an obvious advantage in this regard.

**How Students Become Dedicated Problem Solvers: A University Case Study on Different Teaching Formats**

The last study to be discussed here concerns a university class that has been taught repeatedly, but in two different teaching paradigms. The content of the class does not change much. It covers philosophy of science and research methodology. However, the class is taught in a traditional teaching paradigm first (before 2014) and in a design-thinking paradigm later on (after 2014).

In the traditional paradigm, sessions include lectures, quiet reading of primary literature, discussions and also group-work. When working in groups, students tackle “fictitious problems”. The results of group-work are reported by single volunteering students.

The design-thinking paradigm shall be described in more detail such that interested readers can replicate or modify aspects of the procedure.

The course starts with an introduction to design thinking including the process model and design thinking mottos. Also, in the first session, students hear of the general work routine in class, how they will work on challenges of academic project partners.

The second session gives an introduction to philosophy of science (ca. 30 minutes). Then, project partners from academia introduce research questions they actually work on. In all cases, project partners have a substantive research interest but have not yet decided on a concrete methodology. All project partners specify their research interests by ending the sentence “I want to find out...”. Then, students form teams of 4 to 6 members based on their personal interests. They will work on the chosen research challenge for the rest of the semester.

This is a sample challenge regarding tele-work from one project partner:

*Increasingly often, employees are allowed to work at their homes. However, at home many factors can cause bad work results. Some people fail to bestir themselves and do not get going; there can be a lot of distraction at home; it can be difficult to communicate with the employer and people misunderstand*
their tasks… I want to find out how good tele-workers differ from bad tele-workers. (Chuiji, 10/27/2014, Powerpoint presentation in class, authors’ translation)

The task of the students is not to answer the research question. Rather, they shall suggest different methods for the project partner to pursue his research objective.

In each of the following sessions, there is a lecture of approximately 30 minutes length. It ends with a statement of design maxims for the development of research strategies. For instance, in Logical Positivism, there is the maxim to start research by going out in the world and making observations, which are recorded in a factual language with as little interpretation as possible. By contrast, in Critical Rationalism there is the design maxim to start with courageous hypotheses and try to falsify them.

Throughout class, teams have a lot of craft material at their disposal. They can use coloured felt-tips, scissors, glue and DIN A2 white paper. In addition, all teams have DIN A2 folders to collect suggestions for their project partners.

In each session, design maxims and madlibs are given out to help students implement what they heard during the lecture. For about 30 minutes, teams brainstorm how their project partners could tackle his or her research objective, following the design maxims of that particular session. During teamwork, music plays in the background. Then, each team presents their ideas (2 minutes) and obtains feedback from the audience (2 minutes).

At mid-term and at the end of the course, project partners come in. Teams present a selection of their ideas and obtain feedback from the project partners. Final presentations are video-recorded. Teams hand over a folder to their project partners including at least 10 different research ideas, reflecting ten different seminar days and their specific design maxims.

During class, the design thinking process is used to overview team activities. In particular, each session has a different point of view (e.g., the viewpoint of Logical Positivism or that of Critical Rationalism). Given this viewpoint, students pursue the phases “brainstorm” and “test prototypes” by generating ideas, presenting them in class and collecting feedback.

In addition to the design thinking process, mottos are used to guide teamwork. For instance, ad mid-term students notice that they present many research strategies the project partners already had thought about. Thus, team ideas seem to provide little additional benefit. Building on this observation, the design thinking motto “encourage wild ideas” is highlighted as a means to come up with yet more surprising and potentially more yielding ideas.

Table 1 summarizes key differences of the seminar before and after 2014.

**Qualitative Observations:** In both teaching paradigms, the seminar receives positive feedback from the students. However, some differences become apparent. First, in the traditional paradigm many students hesitate to tackle fictitious problems. At best, groups seem driven by single “leading students”. Without them, group work tends to be sluggish. While some students seem interested, others seem rather bored. When teams are asked to report their results, most students remain silent. Generally, the atmosphere is rather serious.

By contrast, in the design thinking paradigm basically all students immediately seem engaged. Throughout teamwork, the room appears lively and students laugh a lot. In team presentations, each student contributes something. Throughout the presentations, the mood seems to fluctuate between
nervousness and having fun. Expressions of boredom are rarely observable. If they occur at all, it is most likely during the lectures.

When looking at one and the same cohort of students in different seminars, their behaviour seems to vary greatly. While teachers of other seminars complain that students behave like school children, doing only what they have to do and trying to limit the tasks they are assigned, in the design thinking class students show almost an opposite behaviour. For instance, in the week before the final presentations, most students decide to stay in class after the seminar has ended, and after the teacher has left, to prepare even better presentations for their project partners. This decision does not only imply an additional investment of time. It also means the students have to take care of heavy and bulky craft materials including piles of DIN A2-pages that need to be taken home and brought back to class the next time. Better grades cannot be a motivating factor for this engagement, because there are no grades in this seminar. Thus, students seem to have a lot of intrinsic motivation and they seem to identify with the jobs they do.

Since more positive effects have been observed in the design thinking paradigm, the class continues to be taught this way.

RESOURCES FOR DESIGN THINKING EDUCATION

To view an example of design thinking education, we suggest the Stanford Design Thinking Virtual Crash Course (d.school, 2012c). There is a process guide (d.school, 2010b) for creative problem solving that lays out objectives of each process phase. The bootcamp bootleg (d.school, 2010a) introduces methods for every phase. The teaching guide helps to prepare design thinking challenges (d.school, 2015a). Mindfulness cards (d.school, 2012a) help to create the typical verve of design thinking projects. Royalty, Ladenheim and Roth (2015) overview several techniques to create verve. Music samples for different stages of the process are available online (d.school, 2012c). Von Thienen et al. (2012) discuss the setup of design thinking spaces. Rhinow, Köppen, Jobst and Meinel (2013) lay out prototyping techniques.

In general, the K-12 lab at Stanford (d.school, 2015b, 2015c) provides many resources for design thinking education. For instance, there are collections of improve-activities (d.school, 2014) and material
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lists (d.school, 2011) describing useful equipment for design thinking projects. There are also sample schedules for design thinking projects at schools (2015d).

Readers interested in books on design thinking might consult Plattner et al. (2009) for an easy to read introduction. Meinel et al. (2015) let different stakeholders including researchers, students, teachers and project partners voice their experiences with design thinking. Creative confidence (Kelley & Kelley, 2013) and the achievement habit (Roth, 2015) describe philosophies, strategies and tools of design thinking. Make space (Doorley & Witthoft, 2012) discusses how to set up spaces for creative teamwork.


REFERENCES


KEY TERMS AND DEFINITIONS

**Comfort Zone:** The behaviours, feelings and solutions someone is familiar with. Since creative solutions often entail the exploration of something new and unfamiliar, interventions to “abandon comfort zones” can support the development of creative problem-solving skills.

**Creative Mastery:** The ability to develop creative problem views and creative solutions.
**Creative Problem View:** A problem view is creative when it is unusual and useful.

**Creative Solution:** The solution to a problem is creative when it is unusual and useful.

**Creative Verve:** A psychological state characterized by a high level of energy, positive emotions towards a subject of interest (excitement, curiosity, amazement), the experience of passion next to a mindset of openness to different viewpoints and new experiences, creative confidence and readiness to persevere.

**Design Thinking:** A work culture where multi-perspective teams seek and solve wicked problems or design challenges by applying a creative problem solving process and using adaptable work spaces.

**Design Thinking Mindset:** The design thinking mottos (focus on human values, bias to action, radical collaboration…) have become manifest in personal beliefs, values, skills and behaviour inclinations.


**Design Thinking Verve:** The work atmosphere aspired in design thinking education. People partake in design thinking verve when they are excited about their projects, use a high pace of work, readily abandon comfort zones, experiment and learn from failures, lean trustfully into the process, regularly experience and share amazement. Verve is an essential element of design thinking. Many interventions focus on the development of verve.

**Look and Feel of Classes:** Cues in education (room setup, appearance and behaviour of teachers and fellow-students) that suggest a specific scenario (e.g., more or less hierarchical), including roles, motives and emotions of stakeholders (e.g., fearful students that shall demonstrate literacy or excited students who want to showcase creative solutions).

**Problem Space:** The range of possibilities how to frame a wicked problem. In particular, the problem space can cover multiple (a) persons/stakeholders, (b) needs and (c) reasons why a major need is unsatisfied at present.

**Solution Space:** The range of possibilities how to solve a wicked problem that is already framed in a specific way. I.e., it is clear what need of what person(s) shall be addressed.

**Wicked Problem (in Design Thinking):** A problem based on unsatisfied needs. Solutions can be better-or-worse, not right-or-wrong. Typically, creative solutions to wicked problems depend on creative problem views.
ABSTRACT

This chapter examines the perceptions of nineteen graduate students’ regarding the incorporation of Project-Based Learning (PtBL) in a Student Affairs class. This chapter demonstrates that not all students in the class were prepared to assume the responsibility of PtBL learning and yearned for a “traditional” classroom environment where instructors provide structure and step-by-step instructions. However, through hard work and the support from the instructor, the students were successful in completing outstanding PtBL workshops. While students reported increased levels of stress and anxiety while creating their workshop, students also reported having high levels of pride and validation once they successfully conducted it. Students reported being taken outside of their comfort zones and reported high levels of personal growth once they successfully completed their workshops. The PtBL research supports the assertion, “with pain comes gain”.

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INTRODUCTION

In the past, learning was primarily teacher-centered. It was facilitated in a classroom environment where the instructor taught and the students passively listened. Lecturing has been the predominant mode of instruction since universities were founded in Europe over 900 years ago (Brockliss, 1996). “Traditional lecturing and note-taking, certified by periodic examinations, was created for a time when books were scarce and costly” (Boyer Commission, 1998, p. 16). While lecture continues to be an efficient method for delivering content, this teaching methodology will fail to develop the full battery of skills and abilities desired in a contemporary college graduate (Duch, Groh, & Allen, 2001). Hart Research Associates conducted an online survey, which showed that employers want colleges to work harder to ensure that graduates have better skills in “critical thinking, complex problem-solving, written and oral communication, and applied knowledge in real-world settings” (Hart Research Associates, 2013, p. 1). Project-based learning (PtBL) has been identified as a teaching methodology that will help students to develop these 21st century skills (Andrés, 2006).

Graduate students majoring in Student Affairs need to take an active role on campus to ensure that services offered and programs designed contribute to student learning. Professional organizations such as the American College Student Personnel Association (ACPA) and the National Association of Student Personnel Administrators in Higher Education (NASPA) have identified competencies that Student Affairs graduates need in order to be professionally successful. Among these competencies are the ability to assess, design, and implement training, the skill to teach others, to lead, to create, to assemble and use data, to evaluate, interpret, and to consult and to actively engage with students and colleagues (ACPA Rubric for Professional Development, 2010). ACPA emphasizes the need for Student Affairs graduates to develop and teach others by including references to fostering student learning and development fifteen different times in their competencies (Rubrics for Professional Development, 2010).

In an effort to develop the active skills required for Student Affairs graduates, a professor developed her class using PtBL strategies. Students in this class were divided into five groups, each of which included three or four students. Students were then given an authentic topic and were asked to create a two and a half hour professional development workshop. During the first two-thirds of the semester, students learned how to conduct a well-designed workshop. The last third of the class was used for the student groups to conduct their workshops. From the initial instruction to the design and delivery phase, the responsibility for learning and teaching shifted from the instructor to the students.

Students were given broad authentic topics within which to design their workshops. Students were then responsible for both mastering the topic, creating learning activities, and conducting a high-quality workshop. First, the student groups identified learning objectives for their workshop and developed assessments to measure the success of their workshop in fostering learning among their peers. Students also created a PowerPoint presentation and conducted interactive mini-lectures around the content. During the workshop, the student groups were required to include a variety of activities every 15 minutes to optimize the learning and engagement of their audience. Examples of the PtBL activities that could be included are simulations, structured experiences, practice, self-assessment tests, role plays, case studies, group discussion, participative lecture, independent study, lecture, or film (Davis & Schenk, 1978). Following each group’s workshop, students conducted a robust self-assessment and were given feedback from their peers, guest experts, and the instructor.

This chapter examines the use of PtBL as a method of teaching graduate students preparing to work in Student Affairs in Higher Education. The chapter attempts to identify the students’ perceptions of
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their successes, challenges, and experiences while participating in a class designed with PtBL. The objectives of the chapter include:

1. How did the class structure align to support the characteristics of a quality PtBL class where students have an authentic problem, create artifacts, have academic rigor, assume responsibility for learning, required to get assistance support, conduct active exploration, present to an audience, implement applied technology, have alliance with group work, partake in assessment practices, and conduct analysis?
2. What did the students in this class feel were the successes, challenges and personal experiences while participating in this class designed with PtBL?

BACKGROUND

PtBL is an instructional method whereby students learn by doing. PtBL is being used in many different disciplines at the undergraduate and graduate level to help college students develop the problem solving and collaboration skills they will need for the 21st century (AACTE, 2010). PtBL can be defined as “using authentic, real-world projects, based on a highly motivating and engaging question, task, or problem, to teach students academic content in the context of working cooperatively to solve the problem” (Bender, 2012, p. 8). PtBL assignments require students to work autonomously over a prolonged period of time in order to complete a realistic product or artifact to solve the problem (Thomas, 2000).

PtBL has many similarities to Problem Based Learning (PBL). PtBL and PBL are both learning designs where students use inquiry methods to promote students’ critical thinking skills (Savin-Baden, 2000). Both are designed using opened-ended questions, build on 21st century skills, emphasize independence of students, and are longer and more multifaceted lessons than traditional assignments (Larmer, 2015). Project-Based Learning differs from PBL because its tasks are closer to professional reality, students must apply their knowledge, and the tasks are usually conducted in a single course instead of in cross-disciplinary learning environments (Perrenet, Bouhuijs, & Smits, 2000). Project-based learning also differs because students finished project is frequently the creation of a product or performance, where students’ finished PBL projects are a paper or presentation. PtBL scenarios are frequently authentic and real world, where PBL uses case studies or fictitious scenarios (Larmer, 2015).

Characteristics of a high quality PtBL assignment include an assignment where students have an: (1) authentic problem (Steinberg, 1997); (2) artifacts (Bender, 2012); (3) academic rigor (Steinberg, 1997); (4) assume responsibility (Bender, 2012); (5) assistance support (Bender, 2012); (6) active exploration (Steinberg, 1997); (7) audience (Bender, 2012); (8) applied technology (Bender, 2012); (9) alliance with group work (Bender, 2012); (10) assessment practices (Steinberg, 1997); and (11) analysis (Bender, 2012). Here is a summary of each:

1. **Authentic Problem:** For a given PtBL assignment, there should be a main question that provides the “overall task or stated goal for the PtBL project” (Bender, 2012, p. 12). It should be clearly stated, motivational, meaningful, and something that the students feel passionately about (Larmer & Mergendoller, 2010). A question or problem serves to drive learning activities (Helle, Tynjala, & Olkinuora, 2006). “A project without a driving question is like an essay without a thesis” (Larmer & Mergendoller, 2010, p. 35).
2. **Artifacts**: PtBL assignments will require students to take the content they are researching and apply it in new and creative ways that are more complex than traditional assignments such as examinations, research papers, or presentations. Examples of PtBL assignment include digital videos, electronic portfolios, websites, poems, songs, art projects, role-plays, newspaper articles, and reports to organizations (Bender, 2012).

3. **Academic Rigor**: PtBL assignments need to have academic rigor that challenge students to use methods of inquiry that push students to think like professionals in their discipline (such as a scientist or historian). A rigorous PtBL assignment also requires students to develop higher-order thinking skills such as critical thinking (Bender, 2012).

4. **Assume Responsibility**: In the traditional classroom, it is not uncommon to view the instructor as the “expert” that transmits knowledge to the novice student who is a passive learner (Cheong, 2008). In PtBL classes, the role of responsibility is shifted to the student assuming more responsibility. PtBL classes require “increased student control over his or her learning” (Vega, 2012, para. 2) where students have a stronger voice and choice in their projects (Larmer & Mergendoller, 2010).

5. **Assistance Support**: Effective PtBL assignments are complex, multifaceted projects that have a sophistication level that may require multiple sources and types of support and assistance. PtBL assignments should be designed that allow students to get help and support from many sources beyond just the classroom instructor such as other instructors, peer collaboration, technical help desk, writing centers, and community experts (Bender, 2012).

6. **Active Exploration**: In PtBL there is a shift of power where the student becomes the active explorer, so that they do not completely rely on the instructor. A large majority of the learning can take place outside the confines of the classroom where students are required to be the active explorers to gather their data (Larmer & Mergendoller, 2010).

7. **Audience**: Traditional assessment is usually conducted in a private exchange between the student and the instructor. In PtBL assignments, students are working on authentic, real-world issues, so it is important that students have a public presentation or posting of their artifacts (Larmer & Mergendoller, 2010).

8. **Applied Technology**: The incorporation of PtBL can enhance students’ 21st century skills, so it is important that students incorporate technology while completing their PtBL projects. Technologies such as academic library online repositories and search engines can be used to research information. Technologies such as email and forums can be used to communicate with group members and the outside world. Technologies such as word processors and PowerPoint can be used to create their reports and presentations. Technologies such as spreadsheets and databases can be used to analyze and evaluate data. Technologies such as blogs, wikis, and web sites can be used to post information to a public audience (Solomon, 2003).

9. **Alliance with Group Work**: Bender (2012) stresses the importance of including group work in PtBL assignments because it is critical to be able to work within a group to solve problems since this is a skill that is critical for the workplace.

10. **Assessment Practices**: The instructor may not be the only one providing feedback and assessment for PtBL assignments. In addition to the instructor, feedback can be provided by peers and also by experts in the field (Larmer & Mergendoller, 2010). Rubrics should be developed to allow students to know their expectations and also to provide a consistent format to allow instructors, guest experts, and peer feedback to be given for PtBL assignments (Bender, 2012).
11. **Analysis:** Following any major project, students should be required to think and/or reflect on their successes, challenges, areas of improvements, and any other learning experiences realized while completing their project. “The project includes processes for students to use feedback to consider additions and changes that lead to high-quality products, and think about what and how they are learning” (PtBL for 21st Century Success, 2013, p. 6).

**PtBL Impact on Creative Problem Solving Skills**

The inclusion of PtBL can enhance students’ creative problem solving skills (Gerhardt & Gerhardt (2009). Creativity can be defined as work that meets the requirements of the task, but is novel and high quality (Beghetto & Kaufman, 2007). Zhou (2012) found the three aspects of PtBL that enhance the development of creativity development include: 1) Students working on authentic projects, 2) Students working collaboratively in groups to find solutions, and 3) Shifting the class from direct teacher instruction to teacher facilitation. The PtBL design moves students away from simply memorizing content to find the “right answers, which results in students simply repeating another person’s meaning. The PtBL moves students toward learning-by-doing, which requires them to use their creative problem-solving skills to create new solutions (Zhou, Kolmos, & Nielsen, 2012).

**PtBL Positive Impacts on Student Learning**

The incorporation of PtBL in a learning environment can have many positive impacts on students. Freeman et al. (2014) conducted a meta-analysis that included 225 studies, which found that student performance had a significant increase ($P < 0.001$) in active learning classrooms when compared to lecturing. The effect sizes indicate that on average, student performance on examinations and concept inventories increased by 0.47 SDs under active learning ($n = 158$ studies), and that the odds ratio for failing was 1.95 under traditional lecturing ($n = 67$ studies). These results indicate that average examination scores improved by about 6% in active learning sections, and that students in classes with traditional lecturing were 1.5 times more likely to fail than were students in classes with active learning (Freeman, 2014, p.1).

Classes designed with PtBL also move the learning environment from a teacher-centered paradigm where students are passive learners, to a learner-centered paradigm where students are active. Bagheri, Ali, Abdullah, and Daud (2013) found that students that are taught using PtBL strategies have significantly better self-directed learning skills. A self-directed learner has the ability to independently identify and achieve learning goals, and take control of his/her own learning (Findley, 2009). PtBL “can increase retention of content and improve the attitudes that students have towards learning” (Vega, 2012, para. 1). Wurdinger and Qureshi (2014) found that courses designed with PtBL design have a statistically significant improvement on five life skills of “problem solving, creativity, responsibility, communication, and self-direction” (p. 286).

Mergendoller, Maxwell, and Bellisimo (2006) found that students with average to low verbal ability skills improved their higher-order thinking skills in PtBL classes compared to traditionally taught classes. Horan, Lavaroni, and Beldon (1996) found that PtBL positively impacts the critical thinking skills of both low-ability and high-ability students.

Students also learn how to work and interact with others when solving problems. Krishnan, Gabb, and Vale (2011) found that the collaboration skills that students learned in their PtBL activities were essential to the positive learning outcomes of students. The researchers in this same study observed that
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the groups with higher collaboration skills also exhibited high levels of communication, participation, and mutual respect. Students working in PtBL classes report their enjoyment of working in groups for PtBL assignments because they can collaborate with new and existing friends (Lightner, Bober, & Willi, 2007). Duch, Groh, and Allen (2001) found that students in PtBL classes develop skills such as teamwork and communication skills.

Verman, Dickerson, and McKinney (2011) found that educators in higher education report they believe that PtBL classes improve student engagement. They also found that secondary students that participated in an applied shipbuilding project were more enthusiastic about learning. A study in an economics class showed that a PtBL unit resulted in higher student engagement (Ravitz & Mergendoller, 2005).

Student Challenges with PtBL Designed Classes

While PtBL has many benefits, there are also many challenges in implementing it in the classroom. One of the defining characteristics of PtBL assignments is that there is an authentic driving question that gives students a voice in finalizing the essential question and also choice into determining how to develop the final artifact to answer the driving question (Larmer & Mergendoller, 2010). This open-ended process can cause higher levels of anxiety in students and take them out of their comfort zone since many students are more comfortable with “traditional” assessments that require a right or wrong answer such as multiple-choice exams (Woods, 1994).

Another defining characteristic of PtBL assignments is that students receive robust feedback on their final projects to include private and public reactions from peers, outside experts, instructors, and others (Bender, 2012). This type of vigorous feedback can be stressful and uncomfortable for students. Hammer, Ronen, and Kohen-Vacs (2012) found that peer evaluation can provide students with “candid, rich, and multiple-perspective feedback” (p. 179) that are valid and significantly correlated with the instructor’s grades (p < .001). However, they found that students experience higher level of stress when receiving feedback from their peers. The data also showed that students’ estimated effort was significantly correlated with their perception of stress level (r=0.23 p<0.05), “meaning that students who admitted to being more stressed also felt that they had devoted more time and effort to the activity” (p. 187).

Additional desirable characteristic of PtBL assignments are that they include high levels of academic rigor and assume more responsibility of their learning. For instance, students are to ground their learning in contexts beyond the classroom and assume more responsibility of their learning through active exploration (Steinberg, Cushman, & Riordan, 1999). This shift is a hard transition for some students and they resist moving toward assuming responsibility of their learning (Caplow & Kardash, 1995). This causes students to become anxious and stressed when they are asked to move away from their traditional learning environment where the teachers give them explicit step-by-step instructions on how to complete the classroom assignments (Gude, 2010). Students can become frustrated when the instructor has now shifted from the teacher to more of a facilitator (Ertmer & Simons, 2006). Students are also required to spend more time and given much more freedom and autonomy when completing PtBL assignments and some students’ struggle assuming this responsibility (Ertmer & Simons, 2006).

Applying technologies into assignments is a characteristic of PtBL, but this can cause many issues and problems. Some instructors do not feel prepared to integrate technology into their instruction and will back-away from incorporating it into their assignments. Another challenge is finding technologies that are supported by the institution so that students can get the support they need and do not have excessive financial burdens placed on them (Moeller & Reitzes, 2011). PtBL learning environments that
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are technology-rich may also result in cognitive overload for the students while they are trying to learn to content and also learn the technologies (Barab et al., 2000).

Assessment for PtBL assignments may be a challenge for instructors. Traditional assignments such as quizzes or exams rely on quantitative data that results in a right or wrong answer by each student. Objective type assignments such as a quiz or exam can be quick and straightforward to grade by the instructor. Students do not complete a traditional exam or quiz when completing PtBL assignments. Students final artifacts may be new and unusual projects such as web sites, online videos, workshops, or reports. Instructors may feel uncomfortable assessing projects in a PtBL learning environment as they are subjective and take longer to grade (Brinkerhoff & Glazewski, 2004). Instructors incorporating PtBL are required to move away from their existing methods of assessment and develop new strategies for assessing PtBL projects by using rubric in conjunction with feedback from other sources (Frank & Barzilai, 2004).

Students are required to work in groups to complete PtBL assignments, and this can be a challenge for students and instructors. Some argue that group work may encourage social loafing by some group members that are carried by the harder working members of the group (Lee & Lim, 2012). Grading group assignments can be a challenge for instructors as it is difficult to find a balance between grading the finished group project and determining each individual’s contribution to the finished product (Cho & Brown, 2013). Some students complain that instructors tend to only grade the final project and do not include a grade for the social dynamics of the group (Lee & Lim, 2012). Completing group projects can also put a strain on busy students as they become challenged to find times for the group to meet (Whatley, 2012).

METHODOLOGY

The students in this research study were graduate students in Student Affairs in Higher Education enrolled in one professional studies course at a mid-sized university in the Midwestern United States. There were 19 students enrolled in the course; 6 (32%) of them identified as male and 13 (68%) identifying as female. The students identified themselves in the following racial demographics: 16 (84%) Caucasian, 2 (11%) African American, and 1 (5%) Hispanic. The ages of students in the class were as follows: 18-24 (58%), 25-30 (26%), and 31-40 (16%). The graduate course was structured in a semester format.

The interpretive framework used by the researchers was Social Constructivism. Our ontological beliefs are that “multiple realities are constructed through our lived experiences and interactions with others” (Creswell, 2013, p. 36). Our epistemological beliefs are that “reality is co-constructed between the researcher and the researched and shaped by individual experiences” (Creswell, 2013, p. 36).

This case study was bound with a single graduate class. The data used in this research study were triangulated from multiple sources to ensure more accurate results (Yin, 2014). The instructor for this course was one of the authors of this article, but she was not involved in gathering any of the data. Two researchers took observation notes at four of the five workshop presentations. One of the researchers took observation notes at a focus group where all of the students in the class were led in self-reflection discussion. Students also completed a hard-copy survey that asked about their experiences using the real-time polling while conducting the workshops. Data from the survey were input into Excel and uploaded to SPSS for quantitative analysis. Upon class completion, one of the researchers conducted semi-structured telephone interviews with seven of the students who participated in the PtBL class to develop a deeper understanding of their reactions to it. Questions for the students included:
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1. Was your PtBL assignment realistic and authentic?
2. How would you describe your experiences completing the PtBL assignment?
3. What successes and challenges did you encounter?
4. What emotions did you encounter?
5. Explain the assessment practices for the PtBL workshop?
6. What did you enjoy most and least? Interviews were recorded with permission from the students and transcribed.

Data were imported into NVivo qualitative data analysis computer software and grouped into common themes.

RESULTS OF FIRST RESEARCH QUESTION

The first research question asked how the class structure aligned to support the characteristics of a quality PtBL class where students have an (1) authentic problem, (2) artifacts, (3) academic rigor, (4) assumes responsibility, (5) assistance support, (6) active exploration, (7) audience, (8) applied technology, (9) alliance with group work, (10) assessment practices, and (11) analysis. Here is a summary of each of these characteristics.

Authentic Problem

The workshop topics used for this class were highly authentic because they were chosen in accordance with UNESCO’s global themes for education (UNESCO, 2015). UNESCO’s work addresses pressing issues for higher education surrounding natural resource conservation and human resource development on a global scale. Information regarding UNESCO was shared and students were encouraged to consider their roles within the greater higher education landscape. The themes used for the workshops for the five group workshops included Intercultural Dialogue, Advancing Social Justice through Technology, Social Transformations, Sustainability, Working Together, and Bridging the Gap and Working Together. The themes were intentionally left very broad, which empowered the student groups to narrow and focus the authentic problem to a topic they were interested in developing or something that would have more meaning for the audience they were presenting to.

Artifacts

Instead of completing a traditional assessment such as a research paper or exam, students were put in groups of three or four and were required to develop and deliver a two and a half hour workshop on an authentic problem. The first eight weeks of the class taught students how to conduct a well-designed workshop, and the last five weeks of the class were saved for the student groups to conduct their workshops. The groups that were delivering these workshops were learning about the topics they researched, learning how to give an effective workshop presentation, and also assuming the role of instructor by teaching the rest of the students in the class about the workshop topic. Students were required to incorporate sophisticated techniques to ensure they had high-quality workshops. First, the student groups needed to develop SMART learning objectives for their workshop that were Specific, Measurable, Attainable,
Realistic, and Time Bound (Doran, 1981). Each group was required to conduct a pre and post assessment to determine if they were successful in meeting their SMART learning objectives. To conduct the workshop, group members needed to create a well-designed PowerPoint presentation to conduct mini-lectures on the content topic. During the workshop, the groups were also required to include a variety of activities every 15 minutes to help optimize the learning and engagement of their audience. Examples of these activities that could be included were simulations, structure experiences, practice, self-assessment tests, role plays, case studies, small group discussion, large group discussion, participative lecture, independent study, lecture, or film (Davis & Schenk, 1978). Groups were required to design all aspects of the workshop to meet the Universal Design for Learning (UDL) framework (CAST, 2015) to ensure accessibility for individuals with disabilities. Group members were expected to work collaboratively and share the workload for research and workshop presentation in an equitable manner, so that one person did not end up designing and delivering the entire workshop.

**Academic Rigor**

To complete this PtBL assignment, students not only needed to become an expert in an area, but they needed to move outside of their comfort zone to complete a two and a half hour workshop that included learning objectives, classroom set-up, group activities, and assessment methodologies. While giving the workshop, students had to move from “simple understanding” to “deep understanding” to be a credible expert. Students were provided with instruction regarding components of an effective workshop, and students were required to demonstrate mastery of those components in their workshops. Group members quickly appreciated the workshop assignment was going to take a huge amount of time, effort, and resources. They came to the realization the assignment was too sophisticated to simply divide the project up into parts and simply assemble at the last minute. To successfully complete an assignment of this level of complexity, the group was required to communicate and collaborate from start to finish to successfully complete the project.

**Assume Responsibility**

Students in this class were expected to assume significant amounts of responsibility to complete their workshop. Each student group in this class was provided with a broad topic for their workshop, and then it was up to each group to determine how best to focus the topic they would use for their workshop. Students had opportunity to express their voice and make choices. The instructor served as a coach, providing guidance, and gave support when needed, but the students assumed responsibility for their own learning. After determining the topic of their workshop, it was up to each group to conduct their own research, find outside experts, determine their own learning objectives, develop their own assessment methods, design their own PowerPoint slides, plan their own active learning activities, and organize all aspects of their workshop.

**Assistance Support**

Students in this class received their help and support from multiple sources. The first half of the class was dedicated to multi-layered instruction that addressed the components of successful workshop design and demonstrated the use of learning activities. The first half of the class employed lecture, assigned
readings, classroom discussions and experiential learning. Articles, videos and fact sheets were posted to the learning management system to support review of key concepts. The volunteer facilitators provided technical support and training in the application of polling software. Students contacted experts in their workshop presentation outside their class to get help and advice. The students also attended workshops given by organizations outside their class to evaluate the process of giving a workshop.

Active Exploration

Students in this class were required to become active explorers to develop their workshops, because none of the content for their workshop was part of the class curriculum. Once the topics were assigned to the groups, it was up to them to independently research the topic and find the resources to complete their workshop. A student expressed their agreement that the students in this class learned by doing by saying, “I think experience is the best teacher; I thought the fact that this class could replicate that in such a realistic way was something that I have not experienced before”.

Audience

For this class, students conducted a workshop that was given publically for their peers, their instructor, and a guest expert. Since half of this class was reserved for the student groups to conduct their workshops, it was truly up to the students to do an effective job teaching the content, so that their peers would learn the material. Most of the students felt that that the student groups did an effective job in teaching the content by saying, “We are able to learn through our experience, and also able to teach something to the class”.

Applied Technology

Students in this class applied many technologies to structure and deliver their workshop. The groups used Microsoft Word to create handouts for the audience and also used Microsoft PowerPoint to create their presentations. Many of the groups reported having challenges in finding times in their busy schedule to get together for face-to-face meetings, so they would use technologies such as email, skype, cell phones, and Facebook to communicate. Students were required to use Poll Everywhere to incorporate real-time polling during their workshop.

Alliance with Group Work

Students were matched into groups of three or four to develop these workshops. Groups were assigned at the start of the semester and students spent many hours in and out of class developing their workshop. The workshop was not a simple PowerPoint presentation where students could divide up the presentation and work independently. The workshop needed to include things to help ensure the group met their learning objectives, so students were required to work closely with their group members.

Assessment Practices

The students in this class were given a comprehensive rubric that would be used for the assessment of their workshop. Each group workshop also had a guest evaluator that was an expert in the content matter
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being presented. Following the group workshop, the group would immediately receive verbal feedback from their peers, from the expert evaluator, and the instructor(s). Each student group also received written feedback from their peers that was provided anonymously.

Analysis

Following each group workshop, students were asked to immediately give a public self-reflection on their workshop presentation. Students also wrote a private self-reflection for their instructor. After all the groups had completed their workshop presentations, all the students took part in a final debrief during the last class where students were given prompts used for group discussions to reflect on their experiences.

RESULTS OF SECOND RESEARCH QUESTION

The second research question asked what the students’ perceptions of their successes, challenges and personal experiences while participating in this class designed with PtBL. The most common themes identified in the data included the following: (1) “traditional” vs. PtBL workshop assignments; (2) feelings of being overwhelmed; (3) learned-by-doing and learned from others; (4) narrowing the topic; (5) group work, (6) fear of feedback; (7) workshops in their future; (8) incorporation of Poll Everywhere, and (9) self-realizations. Here is what the students reported about their experiences.

“Traditional” vs. PtBL Workshop Assignment

Students in the class compared this PtBL assignment to a “traditional” assignment. Many students reported the eagerness to simply be “done” with traditional group papers and presentations with one student saying, “I am just happy to submit it. I am just happy to be done. I feel I have a check mark, it is done”. However, students felt that this PtBL workshop was considerably different from a “traditional” assignment and they were highly engaged. Most students felt that the PtBL workshop assignment was too complex to simply break it up and then piece it together at the last minute, as they would frequently do with most “traditional” presentations. The PtBL assignment required the groups to develop a cohesive workshop that required all workshop learning components to align. One student highlighted the need to work together throughout the entire development of the workshop by saying:

In other [traditional] assignments . . . we are able to split the work and then just put it together. I know that is not an ideal way to work, but sometimes in group projects, it is so difficult to find the time to get together. So we split it up and we put it all together and sometimes it is not cohesive. [With previous traditional presentations] I just know my part and the other just know their part. With this project, it was engaging right from the very, very beginning. We all did research, we all had to create activities, we all had to come up with the objectives, and we had to come up with ways to measure the objectives. We had to compare research, analyze it, and come up with activities that will help us meet our objectives. So, there was a lot of working together.
Feelings of Being Overwhelmed

The majority of students reported they had never been required to conduct a workshop that included this assignment’s level of complexity before. Therefore, most students initially felt overwhelmed and expressed being taken out of their comfort zone. One student summarized this feeling by saying, “I just think that to me this project was the most challenging that I have had in this program so far. I really stressed out”. Students felt that this caused stress and anxiety while they were in the process of creating their workshop. One student reported, “This was without a doubt, the hardest class I’ve ever gone through. It wasn’t the content. It was the work. I lost sleep. I was anxious. I was stressed out most of the time.”

Students quickly realized the workshop assignment was going to take a huge amount of time and effort to complete this project by saying, “This one was very intensive. If it was done correctly, you met with your group A LOT. I think that my group put in 20 or more hours together. This was intensive.”

Learned-by-Doing and Learned from Each Other

In this class, significant responsibility for learning was turned over to the students, shifting the class from teacher-centered to a learner-centered environment. There were students that appreciated the shift of responsibility who said, “Any student that feels a sense of personal investment in the subject matter, they are going to get more out of it”.

Students also reported that they were able to learn from each other by saying, “I think it was so helpful in how we learned our own content, how we learned the content from others, and how we learned to do something by pure experience. I think that was something that was really valuable”. As students watched each group conduct their workshops, they were able to learn and make adjustments to their own workshops. One student summarized this feeling by saying:

Yes, we were the third group to go. There were two before us and two after us. I think that was a perfect position because we saw the first couple of groups. Now that we’ve seen some we know we’re on the right track, or maybe we need to adjust things.

The students enrolled in this cohort actually reached out to previous cohorts to get their thoughts and feelings about this assignment.

I just heard that during this course you had to build a workshop. Some were very dramatic on how difficult it was for them. And some said it was their most difficult assignment in the program thus far. They mentioned it was difficult because people would come in, and your peers will critique you. You will have an expert in that specific topic to see if you’re going through the correct information. They mentioned it could be intimidating, but if you did it in the way a good workshop should be done, it could be fun and engaging.

While the students in this class felt they were taken out of their comfort zone, they felt that this helped them to learn new skills. One student reported:

The only way you learn is by pushing the boundaries a little bit. The helpful thing was that we had enough support in the class that it was okay. I think the facilitators did a really great job of saying ‘do
not worry about this, you can do this, just focus on this’. They were very helpful with trying to guide us and keep the anxiety down. They were very much available. I thought that was helpful.

Narrowing the Topic

There was a mixed reaction from the students regarding the broadness of the topics they were given to create the workshops. Some appreciated the autonomy and some did not. The students that were happy to be given the ability to focus their topic felt it allowed them to be creative and feel more empowered. One student expressed this feeling by saying:

*I think the biggest success we had was having the autonomy to research a topic and make it our own. I think it made us really think about what is going to be the important information in our field to deliver to the faculty, staff, and students.*

However, not all the students were comfortable being given the autonomy to narrow the scope of their workshop topic. This took some of the students out of their comfort zone, as they were more comfortable being told exactly what to do when completing a “traditional” assignment. One student summarized this thought by saying, “I was angry because I am a student whose style is very much about give me the details. What do you want? I want structure, and this was very [much] unstructured and I didn't like it.”

Group Work

The instructor did not identify any roles in the groups, so it was up to the students to develop their own roles for each group. Some of the groups struggled identifying the roles. One student summarized their rocky start by saying:

*I think there were times my group members did not like me very much because I am very direct. I told them that we have so much work and they didn’t realize how much we needed to get done. We were not even close to getting it done. We needed to get started doing research and develop the project. I created a binder of what needs to be done and a schedule of when it needed to be done. They [finally] realized they needed to work, but the process was frustrating.*

Students in the class reported feeling that group work was hard with comments such as, “Group projects are horrible. I like every single member of the group, but it was frustrating and exhausting”. However, most students felt they were able to work through the challenges of the group and develop positive feelings among the group. One student said that one of his/her group mates told him/her at the end of their workshop, “Now we know how to work together and we’ll definitely work together for the rest of the program. We learned how to work [together] and we learned about ourselves”.

Fear of Feedback

Once each workshop was completed, members of the group would immediately receive verbal feedback from their peers, from the expert evaluator, and from the instructor. Each student group also received anonymous written feedback from their peers. Students reported that this was the first time they had re-
ceived so much feedback on an assignment by saying, “Normally . . . you get feedback from one person, the professor. But getting feedback from a panel of experts, feedback from your grades, and feedback from my peers—it was the first time for me getting that much feedback”. Students reported feeling high-levels of stress at receiving such robust feedback from this assignment. One student articulated this feeling by saying, “We approached it a little bit differently because we were all more nervous about this assignment. We knew there would be a content expert, our instructor, and co-facilitators all watching and evaluating on very specific things”.

The students in this graduate class were in the first year of a two year cohort. Many of the students reported feeling worried about providing feedback to their peers since they would be spending so much time with each other.

*I think as human beings we are open to listen to positive feedback. We are very happy to hear about how we are so good at something. We love to hear we are amazing at doing certain things. But we do not like to hear when we make mistakes. That is why this class was so difficult for us. As a cohort we are going to spend another year together so didn’t want to create any bad feelings or frictions among us.*

Students realized that giving feedback to each other was not as easy as they thought it was going to be. One student wrote:

*I think we were trying to figure [out how to give peer feedback] because in our minds there is either positive feedback or negative feedback. It took us awhile to realize that, wait a minute, this is not about telling you that you are bad at this, it is about suggesting that this could have been done differently.*

The students in the class were surprised when the anonymous written peer feedback that provided to the students after their presentation was much more direct and honest than the verbal feedback they had received following their presentation. One student expressed:

*I realized it was easier to give written feedback than actually verbalize it. When I read the feedback on my written evaluation, I was like, WOW, these people are cruel. I knew that I was going to read things on the written feedback that were totally different than the verbal feedback. I knew they were going to be more open and give me more constructive feedback.*

**Workshops in Their Future**

Almost all of the students reported being extremely happy with learning the process to conduct an effective workshop because they felt that they would need to conduct workshops in their future. Some students said that they were replicating the process to create a workshop in the internships that they were completing at the moment. One student expressed:

*I have already used what I’ve learned outside of class. It was very helpful to have that class the same time I had my first internship because I was in charge of developing their training. Part of that was writing down their objectives and outcomes, and working on how to layout their training to better facilitate it. So I’ve already started using what I learned in class.*
Incorporation of Poll Everywhere

One of the requirements for this workshop assignment was that the student groups were required to incorporate real-time polling by using Poll Everywhere to query their audience. The student groups used real-time polling to assess their audience for learning gains, to get their audiences opinions on controversial topics, and also to get their audience’s opinions on topics. Almost all the students reported being happy with the incorporation of real-time polling with 95% of the students reported being happy with how their group incorporated the real time polling, and 84% reporting it was easy to create the polls. However, there were some students that had challenges incorporating Poll Everywhere into their workshop presentation. One student reported having cognitive overload since he/she needed to learn how to use Poll Everywhere the same time he/she was creating the workshop by saying,

*I have found that it is more difficult to learn content if I am also trying to learn a new technology to complete the assignment. Training with technology, using it in the classroom, and integrating technology is important, but either the technology or course material must first be mastered to enable learning the other most effectively.*

One of the challenges for instructors when incorporating new technologies into their PtBL assignments is that students will experience technical issues. Thirty-two percent of the students reported that they had some technical issues while using Poll Everywhere for their real-time polling. One student reported issues with the Mac users by saying, “The Mac users had a little trouble as it took much longer for the questions to show up on their computer”. Since this class was at the end of the day, several students reported issues with their cell phone batteries for the real-time polling. One student expressed their concern about battery life:

*I did not like using my phone for Poll Everywhere because my battery life is 10% by the end of the day (class time) and I don’t want to use the last bit of power for Poll Everywhere. I’d rather save it for the 40 min. drive home for safety reasons.*

Self-Realizations

Although students reported being highly stressed and anxious while creating the workshop, they also reported being extremely proud of themselves when they successfully conducted it. One student reported, “I think that this project was a lot more complex than a traditional assignment and a lot more rewarding. I felt a sense of accomplishment because it was something I hadn’t done before”. Another student reported his/her feelings by saying, “Thrilled. The fact that someone was so interested in what we had put so much work into was really validating for me”. Another student reported his/her pride by saying, “I was really proud of myself. I thought, ‘I put this together, WOW, after so many hours’. After 30 hours of group work and individual work, this was good. I think that was validating”.

Once students were able to look back on their learning experiences completing the PtBL workshop, they were able to move beyond their discomfort and appreciate the knowledge they gained. One student reported, “I enjoyed the learning experience. What stayed with me [is] that I am going to be able to transfer [the information that I learned] to other classes and even my professional career”. Another student reflected back and expressed his/her level of satisfaction by saying:
I would like to think that the workshop project was one of the greatest learning experiences that I have had in any education. Any format. Just because everything was so intentional, everything had to be built into a certain level in order to be successful.

Many students felt that conducting a workshop that required such high levels of intensity to complete allowed them to grow and develop. One student stated that, “Without all the stress and all of the adjustments and uncomfortable moments, I wouldn’t have learned and grown as much as a student”. Another student felt that he/she will be a more effective group member in the future and said, “I grew as a group member because now when I go into a group situation, I am less likely to be a dominant individual”. Students also came to the self-realization that being forced to move out of their comfort zone allowed them to learn new skills. One student expressed, “It pushed me out of my comfort zone, and that is where you learn”.

SUMMARY OF RESULTS

The instructor in this graduate course designed her class to use PtBL strategies to enable students to take responsibility for their learning and to move away from teacher-centered lecture based instruction. Students were provided foundational knowledge, skills, and support, but then were required to take responsibility for their own learning and for the learning of others. As the class progressed, many of the students were not pleased with the change in role responsibility and yearned for the days the instructor provided the comfortable structure ordinarily provided in a “traditional course”. There were several students in the class that were vocal about their feelings of being overwhelmed. The complexity of the workshop assignment did not allow students to break-up their project and simply put it together at the end as they did with a “traditional” group presentation assignment. Instead, students were required to work closely with group members to create a workshop that was cohesive from start to finish. This required students to spend considerable amount of time collaborating and researching. Students also received public feedback from their peers, outside expert evaluators, and the instructor(s) following their workshop presentations. Many students reported high levels of stress and anxiety while participating in this class. Yet, when students had successfully conducted their workshop presentations, they reported being extremely proud of themselves for completing such a complex, high impact, and career relevant assignment. They reported being happy to have acquired the skills to conduct this type of workshop because they felt that they would use these professional skills in their future. Students reported having grown in their personal skills, their professional knowledge, as well as having become a better group member. Upon completion of the workshop assignment, students reported that they valued the assignment and rated it as being one of the most effective activities that they had ever completed.

CONCLUSION

Classes designed using PtBL can allow students to enhance their creativity, develop their 21st century skills, complete projects that are academically rigorous, and develop authentic real-world capabilities. However, PtBL projects are extremely time-consuming for students to complete and are also extremely time-consuming for instructors to develop, facilitate, and assess. While PtBL projects can be rewarding
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for students, they can also be stressful and overwhelming for students to complete. Therefore, instructors should be strategic when implementing PtBL into their classes to ensure that these projects are intentionally spaced throughout a student’s academic career to ensure students have the time and energy to successfully complete them. Academic programs need to work together to determine the best classes to include PtBL as it would be impossible for students to complete such large-scaled assignments in each of their classes.

SOLUTIONS AND RECOMMENDATIONS

Instructors that are considering implementing PtBL in their classroom should expect students to have similar reactions to those experienced by the students in this study. The researchers of this article want to give encouragement to faculty who are hearing grumblings from their students when completing PtBL assignments. From the onset students resisted taking control of their learning, manifesting this resistance through verbalization of their stress and anxiety. With reassurance from the instructor and considerable work, students were able to conduct well-executed, high impact workshops. Despite the pain of hard work, students reported gaining high levels of satisfaction and pride in their accomplishments. Instructors should prepare to hear some initial complaints from students when being jettisoned from their comfort zones and asked to depart from “traditional” assignments in favor of more complex PtBL assignments. It is often the case that students do not realize the benefits of completing a PtBL assignment until after the project is complete.

Instructors that are implementing PtBL should develop PtBL assignments that move beyond content acquisition and require students to implement new processes and new technologies. Students overwhelmingly reported that learning the process to structure and deliver workshops was valuable and contributed to their ability to design workshops in the future. One student commented:

I think it should be required. Technology is the future of education and real-time polling is a great teaching tool. When used in a class like this, it is considered practice in my opinion and having that opportunity to improve your skills is always beneficial.

The researchers of this article also want to encourage faculty adopting PtBL practices to allow public feedback to the students from their peers, outside expert evaluators, and the instructor(s). The practice of public feedback runs counter to the “traditional” practice where the student receives feedback in private, written form, from the instructor. The use of public feedback allows students to learn from each feedback session and gain valuable experience offering constructive, meaningful feedback to others. One student gave his/her thoughts on public feedback with the following suggestion to faculty:

Constructive feedback, it’s hard to hear that someone doesn’t like what you did. Guess what, you’re going to have to get used to it. You get constructive feedback in your professional life. It’s better to learn how to do that now than it would be for later.
FUTURE RESEARCH DIRECTIONS

A recommendation for further research would be to interview students in the future to understand their current on the job perceptions of the learning value of the PtBL workshop assignment. Since most of the students in the class were overwhelmed by the demands of completing the PtBL workshop, it was difficult for them to appreciate the full benefits of the experience until it had ended. The researchers would be interested in studying students’ perceptions of the PtBL workshop assignment in comparison to more “traditional” assignments once they are employed and need to design learning experiences as part of their job requirements.

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Students' Learning Experiences in Project-Based Learning (PtBL)


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KEY TERMS AND DEFINITIONS

Active Exploration: Shift from students being passive learners where the teacher provides most of the information to the students becoming the active explorer to uncovering the majority of the information.

Analysis: In a PtBL project, students are expected to examine and reflect on their experiences to grow from identifying their strengths, challenges, areas of improvement, and other personal insights.
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Applied Technology: PtBL assignments require students to incorporate technology while completing their PtBL assignments so that students can enhance their 21st century skills.

Artifact: Completed projects that students complete that are more complex than an exam or research paper. Examples of an artifact include digital videos, portfolios, and websites.

Assessment Practices: Traditional feedback on assessment to students is provided from the class instructor to the student in a private format. Feedback in PtBL can be given to the student from multiple sources such as guest experts, peer feedback, community members, and instructors.

Assistance Support: Levels of support provided to students completing PtBL that go beyond those typically found in the classroom environment. Examples include outside experts, technical help desk, writing centers, and community members.

Audience: Traditional assessment in education is shared between only the student and the instructor. PtBL assignments open up assessment to be shared with a wider audience that may be public.

Authentic Problem: Projects that students complete that are real to them compared to assignments that do not resemble any kind of work that would be completed outside a school environment.

Project-Based Learning: Project-based learning (PtBL) is a method whereby student learn by doing that is used in many different disciplines and many different age groups. PtBL requires students to solve an authentic, real-world problem that students have found to be highly motivating and engaging.
Chapter 16

Advocating Problem-Based Learning and Creative Problem-Solving Skills in Global Education

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ABSTRACT

This chapter aims to advocate the development of Problem-Based Learning (PBL) and creative problem-solving skills in global education, thus describes the theoretical and practical overviews of PBL and creative problem-solving skills, the significance of PBL in global education, and the significance of creative problem-solving skills in global education. The application of PBL and creative problem-solving skills are critical in the educational institutions that seeks to serve the educational administrators and students, increase educational performance, sustain competitiveness, and fulfill expected accomplishment in global education. Therefore, it is required for educational institutions to utilize PBL and creative problem-solving skills and develop a strategic plan about PBL and creative problem-solving skills towards satisfying the requirements of the educational administrators and students. The chapter argues that advocating PBL and creative problem-solving skills has the potential to improve educational performance and reach strategic goals in global education.

INTRODUCTION

The complex and fast-evolving world requires young students to possess the problem-solving skills more than ever (Akcaoglu, 2014). The real-world problems require the learner to use metacognitive skills to monitor the problem-solving processes, to reflect on the solution processes, and to establish rationales for the proposed solutions (Çevik, Haslaman, & Celik, 2015). As every difficulty to be removed is a problem, it is required for the individuals to have the problem-solving skills and use these skills in their daily lives (Karabacak, Nalbant, & Topçoğlu, 2015). In the new era of information technology,
problem-solving skills are vital for students to master the world-class knowledge and contribute towards establishing educational society (Ngang, Nair, & Prachak, 2014).

Problem-Based Learning (PBL) deserves a more prominent place in global education, because the PBL process empowers students to assume responsibility for analyzing problems and establishing the educational solutions towards encouraging students’ creative problem-solving skills. Having students work on solutions to problems encountered by stakeholders provides all parties involved in the PBL process with a framework for extending the learning opportunities in global education (Etherington, 2011).

To develop students’ skills of creative problem solving is one of the goals of PBL (Chen, 2008). PBL can promote students’ problem-solving skills and help cultivate the problem solvers who can work with the local learning community as the innovators of global education. PBL method is effective in the development of students’ problem-solving skills in global education (Günüşen, Serçekuş, & Edeer, 2014).

PBL is an instructional approach that is intended to facilitate the prior knowledge activation, the critical analysis of arguments, and the promotion of the insight into scientific perspectives (Loyens, Kirschner, & Paas, 2012). Loyens et al. (2015) stated that problems used in PBL entail several features that can promote the high levels of cognitive engagement. PBL is an effective approach for academics to enrich the students’ social learning practices (Orsmond & Zvauya, 2015). PBL is the development of students’ higher-order thinking skills (Ersoy & Başer, 2014). PBL is an important process for realizing the effective learning where learners are responsible from learning (Art & Katrancı, 2014).

The strength of this chapter is on the thorough literature consolidation of PBL and creative problem-solving skills in global education. The extant literature of PBL and creative problem-solving skills provides a contribution to the educational administrators and students by describing the multifaceted applications of PBL and creative problem-solving skills to appeal to the different segments of PBL and creative problem-solving skills in order to maximize the educational impact of PBL and creative problem-solving skills in global education.

BACKGROUND

The aim of education is to provide students with opportunities to learn the effective problem-solving skills for the issues that they experience on a daily basis (Erdem-Keklik, 2013). The skills of problem solving, critical thinking, and communication are essential for all high school students in the 21st century (Carlsgren, 2013). Helping college students as professionals who are able to deal with the real-world problems in the complex and dynamic situations is one of the essential goals for higher education (Choi & Lee, 2009). Higher education practitioners may facilitate the development of problem-solving skills through conducting the brainstorming session (Rodzalan & Saat, 2015).

Case-based methods (e.g., PBL) have attempted to develop the students’ expertise towards solving the specific problems (Arts, Gijselaers, & Segers, 2006). Problem is stated as situations that the individual cannot solve with present information (Bransford & Stein, 1984). Problem solving in the real-world contexts involves multiple ways of knowing and learning (Tan, 2007). Heppner and Krauskopf (1987) used problem solving as synonymous with coping with the problem. Problem-solving skill is a teachable skill, which helps finding the effective solutions to the individuals’ problems (Conger, Rueter, & Elder, 1999). Problem-solving skills training is recognized as a method of short-term intervention is effective in increasing students’ self-regulation of learning (Griffith & Ruan, 2005).
PBL originated at the McMaster School of Medicine in Canada in 1965 (Berkson, 1993), and was refined by Dr. Howard Barrows as both a curriculum strategy and a process approach in 1988. Since its advent, it has been implemented worldwide in many disciplines and on many educational levels (Hung & Loyens, 2012). PBL is an instructional method in which students learn through the problem solving (Hmelo-Silver, 2004). PBL is a student-centered approach to learning, which enables the students to work cooperatively in small groups for seeking solutions to problems (Rideout & Carpio, 2001). PBL encourages the focused learning based on relevance to the students’ identified objectives, ensuring that the process of knowledge acquisition is effective and efficient (Wee, 2004). Regarding PBL, students are able to acquire an integrative body of knowledge as well as a host of skills (e.g., problem solving, self-directed learning, and group dynamics) in global education (Wee & Kek, 2002). Kong et al. (2014) indicated that PBL presents students with a problem to apply previous knowledge and acquire new knowledge.

PBL has gained importance in the modern era of higher education (Shinde & Inamdar, 2013). PBL is learner-centered (Barrows, 1996). PBL promotes the active learning processes by students (Moust, Van Berkel, & Schmidt, 2005). PBL approach helps students make sense of information, to improve the effective problem-solving skill, to acquire the lifelong learning skills, to improve effective collaboration, and to improve intrinsic motivation in learning (Hmelo-Silver, 2004). Problem-solving skills training enhances the lifelong learning of students (Boihuis, 2003). Lifelong learning and knowledge management have become a fundamental goal of educational policies, both at a national and international level (Kasemsap, 2016). PBL approach is one of the good examples of constructive learning method (Savery & Duffy, 1995). Characteristics of PBL can be explained by a cognitive information processing theory suggesting that learners need to be stimulated to activate information that they know (Wimmers & Lee, 2015). Constructive learning theory asks learners to be active participants during the learning process and to construct the new information according to their meanings (Ari & Katranci, 2014).

ADVOCATING PROBLEM-BASED LEARNING (PBL) AND CREATIVE PROBLEM-SOLVING SKILLS IN GLOBAL EDUCATION

This section describes the theoretical and practical overviews of PBL and creative problem-solving skills, the significance of PBL in global education, and the significance of creative problem-solving skills in global education.

Overview of Problem-Based Learning (PBL)

As mentioned above, problem-based learning (PBL) is a teacher-guided, student-centered, and pedagogical method that is based on independent learning and problem solving by students (Luo, Zhou, Luo, Song, & Liu, 2014). PBL is defined as a problem presented to a small group of students (Lalonde, 2013). The basic learning unit of the PBL approach is the tutorial group comprising six to eight students and a tutor (Newstetter, 2006). PBL emphasizes mobilizing the motivation of students to find their own solutions to problems (Li, 2010). The aims of PBL method are to stimulate the students to solve the realistic problems, to activate the higher cognitive levels, and to organize their own learning process (Wolterling, Herrler, Spitzer, & Spreckelsen, 2009).
PBL represents a paradigm shift from traditional teaching and learning philosophy (Hung, 2011), which is more often lecture-based teaching to a model that is more about student-centered learning. Working in groups, students identify what they already know, what they need to know, and how and where to access the new information that may lead to the resolution of the problem. Regarding PBL, the role of the teacher is to facilitate learning by supporting, guiding, and monitoring the students’ learning process in global education (Schmidt, Rotgans, & Yew, 2011).

In PBL, scenarios related to real life are used as a point of departure for the learning process (Dahlgren & Oberg, 2001). Konings et al. (2005) indicated that PBL is an educational approach that emphasizes the interpersonal skills, self-directed learning, and problem-solving skills. The designs of problems used in the PBL course can have an impact on student learning, such as students’ self-directed learning process (Hung, Mehl, & Holen, 2013). Self-directed learning includes an additional premise of giving students a broader educational role in the selection and evaluation of learning materials (Loyens, Magda, & Rikers, 2008). Wijnia et al. (2014) indicated that the proponents of PBL emphasize the importance of students’ active roles during the learning process towards having them actively construct their own knowledge based on multiple information sources. Schmidt et al. (2009) indicated that one of the essential goals of PBL is to develop the autonomous learners and enhance the students’ self-directed learning skills.

In order to explore the learning processes, PBL requires students a search for information, management skills, and communication skills (Ääri, Elomaa, Ylönen, & Saarikoski, 2008). The information literacy skills developed as a result of PBL are highly transferable to the research context that is self-directed and involves reviewing large amounts of literature (Li, 2013). Regarding PBL, educational strategy uses the real problems as a context for students to learn and has been chosen for curriculum delivery in many professional schools around the world (Hande, Mohammed, & Kombattil, 2015). Students in the PBL environment agree more on constructivist assumptions of cooperative learning and the use of authentic problems, while students in the traditional curriculum acknowledge the importance of motivation to learn more (Loyens, Rikers, & Schmidt, 2006).

Learning in PBL takes place in a dynamic environment, and student interactions make a substantial part of the PBL process (Al-Kloub, Salameh, & Froelicher, 2014). Lalonde (2013) explained that PBL can be divided into three learning sections. For the first section, which is done in a small group, the students analyze the problem, build a hypothesis, and define the personal work. The second section is done by each student and requires the students compile information on the problem from electronic databases, the library, and experts in the field. The student must understand the information and prepare for presenting his research and reflections from what he learns from his peers. The third section, which occurs a week after the first section, is a group meeting where each student presents their findings.

Lin et al. (2010) indicated that there are five steps in the PBL process (i.e., the analysis of problems, the establishment of learning objectives, the collection of information, summarization, and reflection). Regarding PBL, elaboration is promoted through answering questions about the case and discussing the case (Heru, 2011). Many aspects of the PBL cycle aim at stimulating students to elaborate on their knowledge (Te Winkel, Rikers, Loyens, & Schmidt, 2006). Wijnia et al. (2014) stated that PBL cycle involves three phases (i.e., initial discussion phase, self-study phase, and a reporting phase). The learning in each PBL phase is cumulative, and strongly influenced by the earlier phases.

Both staff members and students sometimes report uncertainties with respect to students’ responsibility during the PBL process (Moust et al., 2005). Selecting and integrating literature during self-study phase can be cognitively demanding for learners (Strømsø, Bråten, & Samuelstuen, 2008). During the selection and integration process across multiple resources, students need to recognize the context and the
Advocating Problem-Based Learning and Creative Problem-Solving Skills in Global Education

learning issues formulated for this problem (Wijnia et al., 2014). Marin-Campos et al. (2004) explained that during the tutorial sessions, students discuss a problem in the small group towards explaining the phenomena in terms of their principles.

Restructuring students’ misconceptions, considered as the conceptual changes, could be promoted through instruction that is designed to help students recognize the conflict between their existing knowledge and the scientific explanation (Sinatra & Broughton, 2011). Instructional interventions intended to promote the conceptual change are most useful when they provide opportunities for students to weigh the scientific evidence in contrast with their prior knowledge (Lombardi, Sinatra, & Nussbaum, 2013). An example of an instructional approach that has these characteristics and was developed with the aim of facilitating the conceptual change among learners is transformative learning (Heddy & Sinatra, 2013). Pugh et al. (2009) stated that transformative learning experiences are those activities in which the learner applies classroom learning to the individual’s everyday life experiences. Additional instructional interventions for promoting the conceptual change involve the self-explanation of major concepts in science texts (Chi, 2000), refutation texts (Mason, Gava, & Boldrin, 2008), and computer simulations (Nussbaum & Sinatra, 2003).

Critical thinking, problem solving, and communication are the major strengths perceived by PBL graduates (Rakhuda, 2011) although there is the inconclusive evidence that PBL promotes the critical thinking in undergraduate students more than the traditional lecture formats (Yuan, Williams, & Fan, 2008). Most studies of PBL have focused on its positive effects on critical thinking (Jones, 2008). PBL, as a method of instruction, has been accepted as a standard method of instruction to improve critical thinking skills (Choi, Lindquist, & Song, 2014).

In PBL, students work in collaborative groups to indicate what they need to learn (İnel & Balım, 2013). The problems used in the learning process are the real-world problems which students meet in their daily lives (Goodman, 2010). Whereas the teacher identifies the academic topic for study, students decide which specific learning issues to pursue (Ertmer et al., 2009). Concerning PBL, teachers guide students to develop their own discussions (Maudsley, Williams, & Taylor, 2008). The key to effective teaching using PBL methods is to present the students with the challenging problem (Larive, 2004).

PBL tends to shift the traditional student and teacher roles (İnel & Balım, 2013). The teacher’s role in PBL is to facilitate the students in their task of knowledge generation and problem solving specific to the case, rather than teaching correct answers (Maudsley, 1999). Teacher seeking to prepare graduates for a profession practically adopt a range of PBL approaches and the setting of tasks that involve students in research activities (Ellis, Goodyear, Brillant, & Prosser, 2008). Tutors in the PBL curriculum are recognized to play active roles in guiding students to develop frameworks for use in the construction of knowledge (Chng, Yew, & Schmidt, 2011).

The purpose of the PBL course is to help students gain the useful concepts from the learning sciences to the teaching application (Siegel, 2012). In PBL, students simultaneously develop the problem-solving strategies, disciplinary knowledge bases, collaborative skills, and dispositions (Drake & Long, 2009). In PBL, students are responsible for their own learning (Chan, 2009). Students who have to generate their own learning issues will experience more ownership of the problem and will be more motivated to discuss the problem more deeply (Rikers & de Bruin, 2006). Undergraduate research (UR) and PBL sessions are similar with respect to the type of skills gained through each (AlAmodi, 2014).

PBL is the posing of a problem to motivate students to learn concepts to work through the problem (Goodman, 2010). PBL is implemented as a small group tutorial in which students work through the learning scenarios (Sahin, 2010). PBL has positive outcomes on both the learning process and the
Advocating Problem-Based Learning and Creative Problem-Solving Skills in Global Education

outcomes of the students (Tayyeb, 2013). Spiers et al. (2014) indicated that students often enter PBL programs with experience, values, and expectations from teacher-dependent learning from high school or other learning situations. Spronken-Smith et al. (2011) stated that the intimidation and threat posed by a new learning model could develop into resistance from students who struggle with the expectations inherent in the self-directed learning.

PBL students retain more of the learned information compared to students in a lecture-based curriculum (Strobel & Van Barneveld, 2009). This is ascribed to a deeper processing of new information, through processes (e.g., elaboration and group discussions) to ensure that new information becomes effectively organized in memory (Schmidt, 1983). PBL method accelerates the learning progress and enhances student satisfaction (Sangestani & Khatiban, 2013). In PBL, students work in the small groups on the complex problems before they have received any other curriculum input about the topic (Barrows, 1986). Working on problems is posited to be interesting for students since the problems present the realistic phenomena (Rotgans & Schmidt, 2011).

Overview of Creative Problem-Solving Skills

Problem solving is regarded as the most important creative cognitive activity in everyday and professional contexts (Jonassen, 2000). Problem solving is recognized as a critical outcome of learning (Solomon, 2005). The characteristic of effective problem solving is a process that consists of different stages (Lavonen, Meisalo, & Lattu, 2002). As Heppner and Peterson (1982) defined, problem solving is a process, which includes cognitive, affective, and behavioral transactions. Problem solving is determined to the direct cognitive and affective transactions, such as behavioral responses with a purpose of internal and external requests to a destination. Hassan et al. (2012) defined problem solving as the higher-order cognitive process that requires the pedagogical ways to improve. Problem solving process is to use knowledge and skills to achieve the educational goals (Ulusoy, Turan, Tanriverdi, & Kolayis, 2012).

Problem solving is a cognitive process of the brain exploring the creative solution to a given problem (Wang & Chiew, 2010). Cognitive development refers to the growth in a range of thinking and learning skills, including language, attention, planning, problem solving, and memory. Lazakidou and Retalis (2010) stated that teaching problem-solving skills could help students to improve the decision-making, self-governance, and responsibility. Problem solving ability is an educational feature that can be learned (Yenice, Ozden, & Evren, 2012) by PBL. Uys et al. (2004) indicated that problem-solving abilities have been shown to be better in students who have received instruction with PBL related to individuals receiving instruction by lectures. Williams et al. (2014) stated that abstract thinking is highly correlated with problem-solving ability that is predictive of better adaptive functioning.

In science, technology or engineering contexts, a problem solver needs a connected understanding of mathematics and the ability to recognize the patterns of similarity and association to execute the planned goals (Burkhardt & Bell, 2007). Learners are exposed to situations involving problem-solving skills that require both self-directed learning and collaborative learning, such as critical appraisal, information processing, communication, and teamwork (Martyn, Terwijn, Kek, & Huijser, 2014). Problem-solving skills are the intellectual, logical, and systematic methods that help individual to deal with specific problems in order to search for multiple choices and select the best solution (Ahghar, 2012). Problems confront individuals by getting more complex and different in the societies where everything changes rapidly and gets more complex (Karabacak et al., 2015). Problem-solving skills are explained by the feelings, reactions, and skills of managing stress in the essence of problematic situation (Coşkun, Garipağaoğlu, &
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Problem solving has been also recognized as a strategy of conflict management (Shapiro & Watson, 2000) in organizations. Educational computer games can help enhance the creative problem-solving skills in the modern learning environments. A peer assessment-based game development approach is proposed for improving the students’ learning achievements, motivations, and creative problem-solving skills (Hwang, Hung, & Chen, 2014). For example, Adachi and Willoughby (2013) pointed out video games possess the good learning principles those promote the problem-solving skills. Learners with hybrid animations show the superior problem-solving performance for problems of different transfer distance related to those in the text-only condition (Scheiter, Gerjets, & Schuh, 2010). Students can learn the problem-solving skills from childhood but the problem-solving skills are developed in the school years (Miller & Nunn, 2001). However, Tarim (2009) suggested that cooperative learning method can be successfully applied in teaching verbal mathematics problem-solving skills during the preschool period.

Being able to effectively communicate in the learning environment requires listening skills towards understanding the causes of the problem (Noller & Feeney, 1998). Teaching the problem solving can improve the emotional experience of neurotic individuals (Stillmaker & Kasser, 2013). Coker et al. (2014) indicated that social problem-solving skills have an indirect effect on the relationship between traumatic stress and moral disengagement.

Significance of Problem-Based Learning (PBL) in Global Education

During the last three decades, higher education institutions from various countries have initiated new programs based on PBL (Mamede, Schmidt, & Norman, 2006). PBL is a well-known alternative approach to traditional disciplinary-based educational programs in higher education (Dahlgren & Dahlgren, 2002). De Jong et al. (2013) indicated that the growth in the popularity of PBL is based on an improved insight into the ways in which students learn and the importance of student-centered learning.

PBL strategy improves the students’ learning and helps them solve the real-life problems by searching the scientific data (Niemer, Pfendt, & Gers, 2010). The transition from traditional learning contexts to PBL can be difficult but once accustomed to it, participants enjoy PBL and gain a range of interpersonal skills (Cooper & Carver, 2012). Graduates perceive that they gain increasing autonomy and self-directed learning that leads to the greater depth and breadth of learning (Chikotas, 2009). Graduates tend to evaluate PBL more positively after entering professional practice then they do at the end of the program (Lobb & Butler, 2009).

PBL is widely recognized in the education of medicine, law, and engineering students (Erdogan & Senemoglu, 2014). PBL method is utilized with computer support (Belland, 2010), simulation (Liaw et al., 2010), the Internet (Lou, Shih, Diez, & Tseng, 2010), technology (Ertmer et al., 2009), and concept mapping (Hsu, 2004). Concept cartoons are one of the major visual tools, which can be used in the PBL environment (İnel & Balım, 2013). Regarding PBL, concept cartoons were designed for adults and were used on posters in London underground in order to teach the science concepts to adults (Keogh & Naylor, 1999). Concept cartoons are cartoon style drawings designed as a stimulus to encourage discussion and to generate scientific thinking (Long & Marson, 2003). In the curriculum, concept cartoons involving two or more caricatures practically focus on the science-specific questions (Naylor, Keogh, & Downing, 2007). Concept cartoons help teachers grasp their students’ conceptual development and advocate students to learn in the PBL environment (Huang, Liu, Lin, & Istanda, 2006).
PBL is also broadly utilized in the education of many health professionals, such as nurses, physical therapists, occupational therapists, and social workers (Azer, 2001). A great many medical schools have turned to the PBL approach to teaching as an alternative to the traditional didactic medical education to teach the clinical-reasoning skills at the early stages of medical education. For medical students, PBL continues to be the major form of instruction in a small-group tutorial setting at the curricular level (Kwan, 2002). PBL is a promising tool to enhance the medical students’ engagement with public health (Hoover, Wong, & Azzam, 2012).

PBL has become an integral component of medical school curricula throughout the world (Groves, 2005). Medical education has modified the learning process of their students from the traditionally based master classes to PBL (Kinkade, 2005). Huang et al. (2013) indicated that PBL is superior to traditional lecture-based teaching for medical students. Vogeltanz-Holm et al. (2014) indicated that incorporating team-based learning activities into PBL curricula that include student discussion is an effective strategy for improving the medical students’ engagement, self-perceived skill development, and performance outcomes for students with lower academic ranks.

PBL has the significant impact on thinking and practice in health science education (Quinlan, 2003). PBL promotes the decision-making process used by clinicians and encourages the bridging of the theory-practice gap (Forbes, Duke, & Prosser, 2001). PBL is an innovative teaching strategy that changes the teaching context and is an effective strategy in nursing education (Fish & Moore, 2005). PBL helps students develop critical thinking to solve problems in their clinical settings, and bridges the gap between theory and practice (Rogal & Snider, 2008). The self-directed learning aspect of PBL promotes the development of nursing students’ ability to think critically, and critical thinking enhances the nurses’ abilities to logically formulate interventions to impact the patient care (Ozturk, Muslu, & Dicle, 2008). Critical thinking is enhanced by PBL and critical thinking enables students to solve problems in the clinical situations (Cooke & Molye, 2002). Liaw et al. (2010) stated that the incorporation of simulation learning activities into problem-based discussion is an effective educational strategy for teaching the nursing students to evaluate and manage the crisis events.

Significance of Creative Problem-Solving Skills in Global Education

Students emerging from schools into the workforce will be expected to be able to work in teams and resolve conflicts in order to solve the various problems in the modern economy (Rosen, 2014). Gagne (1980) stated that the aim of education is to teach people to think towards becoming the better problem solvers. So a major challenge for education and educational research is to build on the present understanding of learning for designing environments for education that are conducive to promoting in students self-regulatory and cooperative learning skills, transferable knowledge, and a disposition towards problem solving (De Corte, Verschaffel, & Masui, 2004). Problem solving has been taught in classrooms for a long time (Voyer, 2011). Educators place problem solving in a hierarchy of skills to be obtained by students (Kramarski, Weisse, & Kololshi-Minsker, 2010).

Creative problem solving is a key learning focus in technology education (Potter, 2013). Problem solving is also one of the main goals in science teaching and is something many students find difficult (Lorenzo, 2005). Instructional approaches that ask students to solve problems prior to instruction have received a great deal of attention (Loibl & Rummel, 2014). Instructional solution should focus on designing the learning resources to be easily integrated into the existing perspective of the lecture-oriented classroom.
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(Choi & Lee, 2008). Educational interfaces should be created as the tools that promote the students’ engagement, communication, and problem-solving activities during learning (Oviatt & Cohen, 2010).

The ill-structured problem solving has gained increasing acceptance as an essential strategy of generating the establishment of higher-order creative thinking skills (Byun, Lee, & Cerreto, 2014). An important skill in solving problems, especially ill-structured problems, is the production of coherent arguments to justify solutions and actions (Cho & Jonassen, 2002). The potential of problem solving has led to a large body of research focusing on the instructional strategies for developing students’ problem solving skills in dealing with ill-structured tasks (Cho & Jonassen, 2002). The ill-structured problem solving involves working on problems that are complex, ill-defined, and real-world (Ge & Land, 2004). Feltovich et al. (1996) indicated that the ill-structured problem solving includes the vague goals and requires the structural knowledge of how concepts within a domain are interrelated and requires the integration of declarative knowledge into the useful knowledge structures.

Metacognitive knowledge and metacognitive skills are linked to problem-solving performance (Pennequin, Sorel, & Mainguy, 2010). Metacognitive components enhance the students’ ability to be the better mathematical problem solvers (Kapa, 2001). Not only the students should have the required the mathematical knowledge of different problem solving strategies, but also they should know how to use those strategies along with monitoring their problem-solving processes using their metacognitive skills (Erbas & Okur, 2012). In order to improve the students’ ill-structured problem-solving performance, externalized support is necessary to facilitate both cognitive and metacognitive processes (Ge & Land, 2004). Song and Grabowski (2006) indicated that the important factor related to the ill-structured problem-solving success is intrinsic motivation (i.e., students’ willingness to persist in solving the problem). Students need externalized support for solving the ill-structured problems (Ge & Land, 2004).

Professional educators have turned to the use of cases in an attempt to help students learn to approach the problem situations in global education (Stepich, Ertmer, & Lane, 2001). The problems used in the research programs should be characterized in order to obtain results that analyze the relationship between conceptual understanding and success in problem solving (Salta & Tzougraki, 2011). Tutored problem solving with the intelligent software tutor is an effective instructional method (Salden, Aleven, Schwonke, & Renkl, 2010). Instruction and feedback are focused on the sequence of problem-solving steps to be performed in global education (Mettas & Constantinou, 2008). Webb (1989) stated that use of feedback for problem solving leads to the high level of elaboration towards gaining the greater academic achievement. Students in the feedback group show the higher problem scores over the no-feedback group (Hall & Vance, 2010).

Solving complex problems creatively requires the involvement of a number of people working on the different parts of the overall problem (Ozturk, Rossland, & Gundersen, 2010). Once the problem is represented, solutions can be derived by finding ways to eliminate the causes of the problem (Ge & Land, 2003). The experimental instruction method enhances the mathematics problem-solving ability more strongly than the traditional instruction (Meijer & Riemersma, 2002). A major reason for indicating problem solving as a perspective of interest to mathematics education is that it emphasizes learning through the past solving experiences rather than through the presentation of theory (Mamona-Downs & Downs, 2004).

By adopting the problem-solving approach to teaching, teachers should consider themselves as the competent problem solvers who are able to develop the various strategies to deal with change in global education (Taplin & Chan, 2001). In problem-solving approaches, students who do not meet the established benchmarks receive the additional evaluation to indicate a specific problem (Albritton & Truscott, 2014).
Collaborative problem solving is becoming popular in school settings (Gu, Chen, Zhu, & Lin, 2015). Going through the process of scientific problem solving with children can be another effective method in teaching young children scientific investigation (Hong & Diamond, 2012). Having students write about their thinking is beneficial for developing their problem-solving skills (Hensberry & Jacobbe, 2012).

**FUTURE RESEARCH DIRECTIONS**

The classification of the extant literature in the domains of PBL and creative problem-solving skills will provide the potential opportunities for future research. Critical thinking is the process of rationally analyzing and attempting to solve a problem accurately and efficiently without relying on assumptions or guesses. The aim of critical thinking is to promote independent thinking, personal autonomy, and reasoned judgment in thought and action. Critical thinking relies on problem solvers to consider the diverse sets of possible solutions before making decisions and acting on them. Future research direction should broaden the perspectives in the promotion of PBL, creative problem-solving skills, and critical thinking skills in the modern learning environments.

Having a more diverse group of students provides an extra challenge to establish the PBL assignment in an appropriate way to fit the needs of the whole group towards promoting students’ creative problem-solving skills. PBL asks for all parties involved to revise their role perceptions that they have encountered in the traditional teaching environments in order to encourage students’ creative problem-solving skills in global education. Academic staff needs to adapt to the role of facilitating tutor rather than lecturer, while students have to be acquainted with feeling comfortable in taking an active role. There is a strong need for students to prepare independently and sufficiently in the self-study, and in order to engage in a successful interaction in their tutorials they have to be active, communicate, and also have the ability to listen and talk to each other towards gaining creative problem-solving skills in the PBL environment.

**CONCLUSION**

This chapter aimed to advocate PBL and creative problem-solving skills in global education, thus describing the theoretical and practical overviews of PBL and problem-solving skills, the significance of PBL in global education, and the significance of problem-solving skills in global education. PBL is an instructional approach that challenges students to learn through engagement in a real problem. PBL is a format that simultaneously develops both problem-solving strategies and disciplinary knowledge bases by placing students in the active role of problem solvers confronted with an ill-structured situation that simulates the kind of problems they are likely to face as the future managers in the complex organizations. PBL effectively makes a fundamental shift from a focus on teaching to a focus on learning. PBL process is aimed at utilizing the power of authentic problem solving to engage students and enhance their learning.

PBL is a challenging program that makes the study of organization change intriguing for students because they are motivated to learn by a need to solve the real managerial problems. In the problem-based approach, the complex, real-world problems are used to motivate students to indicate the principles they need to know to work through those problems. PBL fosters the ability to identify the information needed for a particular application, where and how to seek that information, how to organize that information
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in a meaningful conceptual framework, and how to communicate that information to others. In PBL, students work in the small learning teams towards bringing collective skills and integrating information in global education.

Creative problem-solving skills are essential for academic and social success. Creative problem-solving skills enable the educational administrators and students to analyze problems, identify problem severity, and assess the impact of alternative solutions. Problem solving is the process by which students acquire knowledge, skills, habits, values, and attitudes. Problem solving includes a variety of learning experiences and it takes place outside the classroom as well as inside the classroom. Problem solving involves both learning and teaching. Using effective problem-solving techniques will help students avoid conflict with others in the educational settings and in their everyday lives. Problem solving ability develops over a long period of time and grows with experience in solving a variety of problems in many different ways. Regarding problem-solving approach, students must learn to be flexible and make use of a variety of methods, techniques, and strategies in global education.

It will be helpful for the educational administrators and students to focus on PBL tutorials with more experienced tutors in order to gain a practical understanding of how PBL tutorials effectively work towards obtaining the improved creative problem-solving skills in global education. The application of PBL and creative problem-solving skills are necessary in the educational institutions that seeks to serve the educational administrators and students, increase educational performance, sustain competitiveness, and fulfill expected accomplishment in global education. Therefore, it is required for educational institutions to utilize PBL and creative problem-solving skills and develop a strategic plan about PBL and creative problem-solving skills towards satisfying the requirements of the educational administrators and students. Advocating PBL and creative problem-solving skills has the potential to improve educational performance and gain sustainable competitive advantages in the information age in the future.

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**ADDITIONAL READING**


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**KEY TERMS AND DEFINITIONS**

**Critical Thinking:** The examination of assumptions underlying current beliefs to evaluate their correctness and legitimacy.

**Curriculum:** The combination of different training courses arranged in a sequence.

**Discussion:** The activity in which people talk about their opinions.

**Education:** The wealth of knowledge acquired by an individual after studying the particular subject matters.

**Learning:** The activity of obtaining knowledge.

**Problem:** A perceived gap between the existing state and a desired state or a deviation from a standard.

**Problem Solving:** The process of working through the details of a problem to reach a solution.

**Skill:** An ability and capacity acquired through the deliberate, systematic, and sustained effort to execute the complex activities.
Chapter 17

Instructional Design Technology in Higher Education System: Role and Impact on Developing Creative Learning Environments

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ABSTRACT

Higher educational Institutions all over the world are grappling with increased student population, several domains of learning and varied disciplines and instructors with varied experiences in using instructional design technologies. The chapter focuses on how it is possible to facilitate instructional design experiences for the stakeholders in higher education for creative learning. The chapter addresses the emergence of Instructional Design Technology (IDT). The role of IDT and its importance in higher educational institutions is studied with current practices in the field. The impact that this field had made in the evolution of instructional frameworks across the different layers of tertiary educational system is studied especially with regard to improving the teaching and learning experiences of educators and students respectively. The role of Creative Learning technologies is discussed based on the success that these systems have enjoyed in improving instructional design.

INTRODUCTION

Research in the area of Instructional Design technology has revealed several gaps in the theory and applied practice. Instructional Design technology implies creating and delivering content for educational purposes using technology driven tools. The aim of using instructional design technology is to capitalize on the available resources, people and time besides also to support creativity, flexibility and archiving of learning materials and artifacts. However most of the learning environments in the educational institu-
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...while being successful in providing all round the clock support to the learners and educators, in terms of availability of resources and feedback on assessments have not been able to support the creative facets of a learner. Emergence of IDT as a field of study

- IDT as a tool of developing creative learning environment
- Importance and Impact of IDT in institutions
- Adaptive Instructional Design Technologies
- Role of adaptive Instructional Technologies
- Match between Instructional Design and Learning Design Technologies

BACKGROUND

The chapter addresses various issues faced by instructors while preparing instructional material keeping in mind the tools they will be utilizing to disseminate knowledge in order to develop a creative learning environment. The chapter provides the perceptions and expectations that a student has of the education that he will receive and the learning experiences that he undergo, need to match the perspective of the instructor and the program learning outcomes. The gaps that are emerged during this process reflect negatively on the students’ performance in the course of his academic career and after. Therefore it is essential that the experiences are formulated with the right amount of instruction and judicious of supporting technology for achieving the goals of the program that the student has enrolled in.

The main focus of the chapter is on the following topics which are covered in detail. Modern learning management platforms face the similar challenges as their traditional counterparts, in that need to be able to involve several challenges as faced by the traditional learning management systems. Integration of creativity in the curriculum is challenging task for the higher education institutions. Cross disciplinary and inter disciplinary curriculums also face the same problem because there is no proper definition of creativity and no proper policy formulations in HEIs. (McWilliam 2007a). Amabile (1997) identified three major components of creative performance which are domain relevant skills; creativity relevant processes; and task motivation. There is systems approach given by Csikszentmihalyi’s (1999) which categorizes domain relevant skills like facts, principles, skill sets and opinions. These skills are needed for the learner and help him to get proper response or possible judgements (Dewett 2003). As illustrated in Figure 1, modern learning environments foster interaction and learning on the go with real world learning environments.

A productive learning environment must have the following characteristics.

- Significant and meaningful interaction between the academic and the learner.
- Inquiry based learning activities.
- Learning activities based on group discussions, project–based activities.
- Emphasis on understanding the learning content.

Several types of learning environment have evolved and institutions are experimented which include Adaptive personalized Learning Management Systems.

Context aware ubiquitous learning is very beneficial for the students for solving problems and acquiring real world knowledge Chu et al. (2010), Rogers et al. (2005). Ogata and Yano (2004) proposed
and develop GPS system which was based on context-aware ubiquitous learning which was used learn Japanese and practice. Hwang et al. (2012) build RFID based learning system which can work on scientific devices in Science Park which can give numerous tasks to the students to operate and will evaluate the results based on their operational efficiency.

Authentic Learning environments are also emerging and it gives new dimension to the curriculum design. The learners and students can learn problem solving and it help them to solve challenging problems also and the student feels the same challenges. The authentic learning environment model proposed by Herrington and Oliver (2000) is a good substitute of alternative instructional model. The systems model “Gagné’s Nine Events of Instruction model” (Gagné, Briggs, & Wager, 1992), offers solutions to complex learning tasks. This model also helps in design and implementation of realistic learning issues. Herrington Reeves and Oliver (2010) extended this model to e-learning environments. In Table 1 the characteristics of modern learning modes are categorized. Authentic Learning environments (Herrington et al, 2014) (Heidi et al, 2015) have explored new technology driven strategies to improve the efficacy of the instructional design process and further optimize the learning process.

WHAT IS INSTRUCTIONAL DESIGN TECHNOLOGY (IDT)?

IDT stands for Instructional Design Technology it involves learners, subject content and learning environment connected to some technology supported platform or device. Instruction advocates the method in which learners acquire certain knowledge in a particular domain from an instructor. (Reigeluth, 1983a) opined that the field of instructional design “prescribes optimal methods of instruction to bring about desired changes in student knowledge and skills” (p. 4).The domain of Instruction Design deals with planning of instructional processes, implementing them in appropriate platforms and learning environments, and evaluating instructional processes and technologies.(Gagne, Wager, Golas, & Keller,2005).

(Gagne et al., 1992) defined the ISD (Instruction System Design) process as an interdependent process involving a series of input, process and output steps that help to achieve a well-defined goal. It has been defined the ISD as a collaborative and integrative system (Gustafson &Branch, 2002). Wang and
Hannafin (2005) further expanded the definition to include interactive and contextual characteristics to this process. In Figure 2 the instructional process followed in Higher Education Institutions is detailed where the Informal and Formal teaching processes are organized into a hierarchical top to bottom approach where the Instructional processes are supported by platforms for knowledge creation, review and dissemination. Higher Education Institutions (HEIs) face several challenges the most serious one is in trying to maintain the quality of instruction and instruction delivery when educational practices all over the world are offered are going through a several rapid changes in all aspects (Middlehurst, 2001).

The instruction design technologies must be evaluated because it affects delivery of educational resources, flexibility of learning. Learner’s specific learning needs, cultural variable, preferences and style are all affected through IDT.

### HOW INSTRUCTIONAL DESIGN TECHNOLOGY SUPPORTS CREATIVE LEARNING ENVIRONMENT

A majority of learning management platforms provides an environment wherein learning content, assessments and instructions are often not customized suitably to reflect on the learners’ cultural background and local environment. Loveless (2002, 2007) undertook a literature review in creativity, new technologies and learning, whilst Banaji and Burn (2006) and Banaji, Burn, and Buckingham (2010) also studied the same.

Creative learning environments create more successful learners compared to currently available learning environment tools besides being able to reproduce the concepts, theories and practices and serving knowledge or learning artifacts. The learner is expected to evolve into a productive, creative
and enterprising individual, as the onus of the learning process does not lie solely on the shoulders of the educators but also with the learner.

The current educational system is creating more mediocre students who have little core workplace skills, technical or non-technical. The onus is on presenting existing knowledge and acquiring a mediocre level of technical skills which do not measure up to the requirements of the industry, research centers or any other career domain. Automating learning through digital means of creating, storing, dissemination has not brought the required results to the area of education in higher educational institutions. Learners are not guided in an optimal manner and often the educator is at loss to encourage learners to participate in the class room activities wholeheartedly. Learners indulge in malpractices and learn, not to satisfy the quest of discovery or innovation but rather to own a college diploma or degree qualification that will help them to secure a placement in the industry. Such learning environments are bound to suffer from student retention issues in the immediate future.

It is desired that educational institutions host educational environments which place significant importance to providing ample opportunities to discover the creative genius of a learner such that students will exit the educational institution as creative, successful, knowledgeable, productive graduates’ skills. Such a learning environment allows for the learners’ cognitive abilities to be fully utilized if the learning environment has the scaffolding to support learner’s creativity and cognition; the creative affordances of technology; and the creative classroom.

Learning environments are the realm of educators, subject experts and training professionals. The successful adoption of a creative learning environment depends heavily on the following factors.

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**Figure 2. Instructional process in higher educational institutions**
• **Cultural Contextualization (Chen, Mashadi et al., 1998):** Henderson (1996) has argued that, “Instructional design cannot and does not, exist outside of a consideration of culture’, and that it impinges on notions of cultural identity and cannot be culturally neutral”.

• **Cultural Inclusivity (Wild & Henderson, 1997):** Collaborative structures for learning- Learning Processes can be considered efficient only if they can deliver to learners and the environment where they gradually acquire relevant skills through constant engagement with subject experts, educational experts and peers in collaborative social environments.

Productive discussions and learning by doing, problem-solving and task management are important skills that graduates need to acquire during the learning process. Learning based on creative tasks and pedagogy is instrumental in capitalizing on the skills, knowledge and expertise of learners. Learners’ who are actively engaged in some vocation or activity of indigenous or cultural importance, appreciate any learning activity only if it can enhance existing knowledge or provide new insights into acquired knowledge especially after the beginner level.

Constant interaction and feedback processes that will navigate learners through the skill acquisition process is another vital structure that needs to be incorporated in learners. Availability of subject experts during the learning process for consultation and advice is integral to the learning process.

Dissemination of knowledge is crucial to creativity. Created artifacts and knowledge structures when shared can generate perfection and simulate research, help like-minded peers to work together on integrating and implementing these systems. Especially in the tertiary education level learners are motivated by learning environments that have a variety of tasks, and are culturally relevant, inform them of their progress, allow learning from mistakes, and promotes creativity.

Creativity is not an individual trait hence learning tasks that are collaborative need to be, envisioned, designed and handed out to learners in collaborative environments. These learning environments need to have transparent workspaces wherein novices learn the basic skills and aim for a higher level of engagement with advanced learners. This engagement needs to be conducted in transparent workspaces as it is imperative that learners, educators and assessors have a clear understanding of the match/gap between skill required and skill acquired by the learner.

Learners are constantly updated about the progress towards the higher goals in the learning curve. Creative Learning environments must allow for diverse solutions to a task. Each solution presented by a learner must be evaluated on the basis of the novelty of the solution, application of concepts learned, evidence of new concepts acquired. Availability of hi-quality, varied and relevant learning material in different formats and support at any time anywhere during the learner to activity engagement is imperative to the Creative Learning Environment.

Learning tasks need to be provided in various formats that include audio / visual /text formats. These tasks need to be presented either as one task or several sub-tasks with a definite goal by the learner completing the tasks in any sequence, which may be envisioned not by the academic but by the learner.

**LEARNING MODELS AND CREATIVITY**

Among the essential components that encompass an educational environment based on learning; the ubiquitous, collaborative and creative aspects are central to the process of learning.
Ubiquitous environments ensure availability of learning and training resources, via digital means and around the clock. It incorporates means for immediate feedback and means of collaboration and communication with peers and superiors. In the age of knowledge explosion and high density of learning material online, learners need guidance and support as they complete their learning milestones.

Modern classrooms need to focus on providing adequate learning with sufficient scaffolds to further inquiry based learning, creativity, just-in-time feedback with feedback on progress.

A teacher is now more of a facilitator in that instead of delivering existing knowledge to his students it will be required of him to metamorphose his teaching skills and experiences to inculcate digital readiness, flair for out of the box thinking and solid grasp of the essential concepts of the domain.

UBIQUITOUS CREATIVE LEARNING ENVIRONMENTS

Definition of ubiquitous learning is “learning anywhere and at any time” (Hwang, Tsai & Yang, 2008; Shih, Chu, Hwang, & Kinshuk, 2010). Ubiquitous computing is referred to “a new chronology which enables people to seamlessly utilize huge amounts and various kinds of “functional objects” anytime and anywhere through network connections” (Rodríguez & Favela, 2003). The significant characteristics of u-learning, which make it different from Conventional e-learning, have been discussed, including seamless services, context-aware services, and adaptive services (Bomsdorf, 2005). In an ideal u-learning environment, computing, communication, and sensor devices are embedded and integrated into learners’ daily life to make learning immersive. Based on this concept, Yang (2006) proposed “a learning environment facilitated with context aware peer to peer search to empower learning resource finding and sharing. For discussion we take the case of a course in Computing and Multimedia, the Interaction Design course deals with Designing interfaces for new and Existing System”.

In such a course, it’s quite challenging to educate undergraduate students who have little or absolutely no industrial experience on the implications of the User Centered Tasks, Data Gathering Guidelines and User Task Analysis without incorporating excerpts from real use cases which appear in the learner’s learning environment when the learner has completed the prerequisite tasks before applying his conceptual knowledge and practical knowledge to address issues in an existing system to envision an entirely new system.

The role of Instructional design in designing a creative learning or adapting an existing system to include creative learning is manifold.

- Connecting learners to peers through specific task specific projects with the flexibility of learning by doing.
- Learners need to produce artifacts of extended knowledge or application. These may be models, critical review of existing practices.
- This learning has to be supervised, and learners reminded about the significance of creativity in the course learning outcome from the stage where concepts and principles have been presented and discussed albeit critically.
- Creativity of the learners’ can be judged by the artifacts produced by the learner and its implied application in a real-world scenario.
- Learners, educators, and other stakeholders need to be connected at all times to provide valuable feedback and timely assistance to the learner group to accomplish their learning goals.
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- The learner needs to know the extent of weightage on creativity in a course to feel motivated.
- Educators or course leaders can determine the tasks that are to be evaluated by the extent of its creative value versus concept knowledge.
- Instructions with flexibility in terms of number of submissions date of submission and pace of work accomplished need to be carefully thought out to encourage students to discover new dimensions to an allotted task than to submit mediocre work within the allotted time.

Studies by (Hwang, 2014) have compared the features of ubiquitous, smart and adapted learning. The three learning models were compared on the basis of the following parameters.

- Detects and takes into account the real-world contexts.
- Situates learners in real-world scenarios.
- Adapts learning content for individual learners.
- Adapts the learning interface for individual learners.
- Adapts learning tasks or objectives for individual learners.
- Provides personalized feedback or guidance.
- Provides learning guidance or support across disciplines.
- Provides learning guidance or support across contexts (e.g., in classrooms, on school campuses, in the library, and on the street).
- Recommends learning tools or strategies.
- Considers the online learning status of learners.
- Considers the real-world learning status of learners.
- Facilitates both formal and informal learning.
- Takes multiple personal factors and environmental factors (e.g., learning needs, preferences, schedules and real-world contexts) into account.
- Interacts with users via multiple channels (e.g., smartphones, Google Glass, or other ubiquitous computing devices).
- Provides support to learners with “in advance adaptation” across real and virtual contexts.
- Provides support to learners with “on the run adaptation” across real and virtual contexts.

In all these parameters creativity was not taken into account and this implies that modern learning environments are still following the old pattern of reproducing existing knowledge with new media.

CREATIVE LEARNING ENVIRONMENTS

The learning environment as we know today is equipped with digital technologies that are able to connect learners and their instructors to unlimited sources of information. These colossal sources of information gleaned from textbooks, educational websites, journals, videos and other formal sources of knowledge cannot guarantee a positive learning outcome unless the information can transform the learner into a creative learner with the potential and ability to arrange, categorize, critique and transform this information into applicable and transferable knowledge. The onus on creativity has made institutions to devise learning to branch into online class rooms and MOOC’s (Massive Open Online Course) to support 24x7 availability of teaching and learning resources and social media platforms where learners can be
creatively inspired by podcasts and video lessons. As learners evolve from “recipients of knowledge” to “architects of knowledge”, educators too become empowered. Educators now interact with a rapidly evolving mass of learning resources, geographically scattered communities of learners’; they direct the learning process to moderate the growing dependence of institutions on digital resources. Personalized Learning Environments (Sunil et al., 2010) have discussed the facets of personalized learning with respect to delivering learning resources to learners in a suitable way such that learners are able to manage their learning at their pace besides acquiring knowledge, and specializing in domains that match their interest. However the concept of creative learners is not discussed in PLEs.

Ubiquitous learning and Mobile Learning Environments mean that location is not a factor for learning process to take place. These Learning Environments instead will ensure the availability and dissemination of instruction and learning at all times. Smart devices are able to provide access to learning resources, learning spaces and learners irrespective of time and distance (Cavanaugh, McCarthy and East, 2014). Contextual learning a “conception of teaching and learning that helps teachers relate subject matter content to real world situations” (Berns & Erickson, 2001, p. 2). However these environments do not explore the creative facets of learning; however creativity can be embedded in all the three learning environments. However all the environments are not utilizing the learning spaces in an optimal manner to inspire creativity and collaboration in learners. The creative learner requires transitional surfaces to explore the journey from information collection to knowledge achievement with measure of creative potential achieved.

The Learning Spaces illustrated in Figure 3 describe the transition that the learner goes through while getting involved in the educational process. The curriculum must chalk out the role of instruction design technology in Creating Creative Learning Spaces. Learning Management Systems and smart learning environments need to adapt to the evolving requirements of learners and academics. Learners interact with Learning Management Systems and educational repositories. Reflection, Discussion and assimilation of educational topics take place in Collaborative Learning Spaces. These Learning spaces are designed to enrich the learning by having a common shared interface which can be edited by the learning group, multimedia rich learning resources. These can be viewed, manipulated to create new artifacts or to assemble the collective perspective of various learners into a single shareable, recorded interface as a digital learning artifact. This digital artifact is to be presented as a desired students’ learning outcome for learning and assessment purposes. The Creative Learning space gauges the extent of creativity or new insights in the created learning artifact as it must be a prototype model or series of technical illustrations that depict a new technique, method or experiment. Multimedia tools and platforms play a major role in assisting learners to visualize, share illustrations, make annotations, and record the materials perused. In some systems like Ingenium (Wood et al., 2013) the learners and academics can collaborate while using this creative learning online tool Ingenium was designed in late 2011 and early 2012. The system was supporting online tool to scaffold educators and students through a creative problem solving approach while teaching and learning, respectively.

**Stages of Learning in Creative Learning Environments**

1. The various stages of learning (see Figure 4) in creative learning environments deals with the different methods to solve teaching assessments. Each solution or method should direct the learner to seek new dimensions outside the concepts learnt in other words exploratory learning on units covered in that unit.
2. The concept can be mastered by learners when they learn how to confidently present artifacts that delve deep into exploring perceptions and results of supervised or unsupervised, group discussions.

3. At the Intermediate level, the learners’ exploratory and creative thinking or holistic approach to the domain can be evaluated by the case studies that are used by the learner to initiate and get involved in group discussions, confidence, accuracy and dexterity in discussing topics of interest in the course.

4. At the advanced level the learners’ critical thinking abilities and knowledge gathered about current practices in the field will help him channel his energy to contribute to research and industry.

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*Figure 3. Learning lifecycle model of creative learning environments*

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*Figure 4. Stages in the creative learning process from basic to advanced units of learning*
Either by preparing research papers in the field or by submitting a proposal to initiate a startup or enterprise within the institutional framework.

FEATURES OF CREATIVE LEARNING ENVIRONMENTS

1. These environments involve encouraging learners to present more than one solution to a problem or different methods to solve teaching assessment.
2. Each solution or method needs to be used further for brainstorming in group discussions and focus on implementation.
3. Student participation rate will be high as the learning depends on incorporating individual perspective and knowledge to complete a task.
4. Emphasis on:
   a. extending existing knowledge
   b. engaging in real work-place tasks that needs to be incorporated in a real world work-place environment
   c. continuous feedback on progress
   d. instant appreciation for creativity
   e. clarity of learning outcomes or goals
   f. closer integration with career paths and choices
   g. greater interaction with professionals in the domain
   h. ability to envision the career paths the learner would like to take
5. Availability of flexible learning environments or space that supports recollection, introspection, recording and support of creative activities completed. Each activity must be rated by domain experts and instructors to instill self-confidence especially in the intermediate and advanced units.

ROLE OF INSTRUCTIONAL DESIGN TECHNOLOGY

As seen in the previous section the existing learning setting leaves little room for developing creativity or even imbibing the importance of creativity in a learners’ psyche. Educational institutions pay more emphasis to guiding learners to acquire concepts and facts through pre-arranged learning material. The concepts are reinforced through various tasks or assignments. These tasks are then completed by the learners according to the instructions provided by the instructor through in class sessions or online learning modules.

There will be an expected known solution available to the instructor and the learners are expected to arrive at the same conclusion at the end of the task. Mistakes or different answers are rarely encouraged or seen as learner’s attempts to explore various means or methodologies to solve the problem. The final answer is evaluated and not the learning steps traversed by the learner to explore, understand or in some cases invent a new dimension to the task or concept presented.

This results in average predictable task submissions or project presentations as learners pay more attention to reproducing existing knowledge than in finding ways to create or invent new solutions to existing problems or discovering new problems in existing situations.
Instructional Design Technology in Higher Education System

In some cases contextual learning can help generate interest in learners as required for creative learning the academic content need to be segregated in theoretical knowledge which needs to be assimilated in the tasks allocated for each topic. The main disadvantage of the learning content is that learners can relate to the theory only on being provided with concrete workplace scenarios wherein the discussed theory may be applied.

The creation of artifacts based on the domain knowledge and segregation of tasks based on creative learning context, the concepts of subjects can be indescribably difficult for students who are not comfortably well-versed with the vocabulary used in text book. The challenge to the instructor is three fold – extracting the meaning of the word within the context of the domain, suggesting suitable examples from IT that incorporate the actual meaning of the word within a suitable knowledge element.

By knowledge element the authors mean the thread of new knowledge that needs to be espoused and comprehended in order to acquire a learning outcome outlined in the course’s learning objective as illustrated in Figure 5. It is therefore imperative for instructors to gauge the learners understanding of the key terms in the domain to discover knowledge elements during task discussions, live demos or project presentations. A successful learner completes a task depending on his tenacity in exploring topics of interest, his awareness and confidence in discovering topics and his ability to present new knowledge.

Figure 5. Creative learning process and intended learning outcomes
IMPRESSION OF INSTRUCTIONAL DESIGN TECHNOLOGY ON CREATIVE LEARNING ENVIRONMENTS (CLE)

The impact of the Instruction Design Technology can be measured by the presence of appropriate scaffolding to support the activities of the learners by integrating various digital media. Educators will find the task of designing instructional environments for creative learning a challenging task that will require a lot of team work and vision.

Course Team leaders will need to incorporate IT experts, domain experts, academics, to build a comprehensive full-fledged system that can extend learning support with scaffoldings that support collaboration, creativity, team bonding and learning support to achieve intended learning or module outcomes.

In this context, it is wise to consider the integration of digital media and mobile devices (iPod, tablet, smartphones), allowing students to set personal goals, to manage educational content and to communicate with others in the right context [Bidara et al.,2010].

Online Repositories housing digital material with built in calendars that guide learners and educators to schedule their learning activities and assessments with their peers or learning groups. Cloud based digital learning spaces that allow learners and educators connect across geographic divisions. Online Discussion boards and online collaborative tools have helped in

Collaborative Learning While the incorporation of small groups into the teaching process has its roots in education theory (Dewey 1943, Vygotsky 1978), researchers and teachers now accept collaboration as an effective tool in K–12 education. In fact, in his introduction to a meta-analysis of educational collaboration research Slavin (1996) called the empirical support for collaboration “one of the great success stories in the history of educational research.” Student collaboration is a proven factor in improving such higher-order traits as student motivation (e.g., Nastasi 1993), problem solving (e.g., Barnes & Todd 1977), inter-personal and inter-racial relationships (Sharan 1980), and creativity (e.g., Giguere 2011), while also improving academic outcomes (see Springer, Stanne & Donovan, 1999, for a review and meta-analysis).

There are several online resources available for education and research. For the purpose of discussion the following are mentioned in the table below. In the table each resource is categorized and its features are presented with due emphasis on support given to creativity and collaboration (Table 2).

INSTRUCTIONAL DESIGN TECHNOLOGY LIFE CYCLE

An instructional Design Life cycle Figure 6 is an illustration of the proposed life cycle for the Instructional Design Process. Here the development iterative steps of topic conceptualization, architecture selection, gaps in existing systems are elicited in the initial stages of the life cycle in the requirement Analysis stage. In the design stage the architecture is selected, modes for learning content dissemination and communication between stakeholders is articulated.

In the development stage user manuals and content systems to store, retrieve and publish learning content is commissioned, followed by the actual rolling out of the instructional content is conducted in the form of digital classrooms supported by online web course management systems, lab sessions conducted by digital instructional material, and e-assessment modules embedded in the learning content. Finally the entire process is evaluated by means of evaluation tools matching of LOs and POs, criteria matching and assessment. Feedback mechanisms through hierarchical approval via program coordinators, course coordinators and subject experts during audit sessions.
### Table 2. Online resources for higher education

<table>
<thead>
<tr>
<th>Sharing and Team Work Collaboration tools</th>
<th>Features</th>
</tr>
</thead>
<tbody>
<tr>
<td>Google Docs</td>
<td>Supports collaborative tasks. Several learners can work on a single document simultaneously. Using the Gmail account learners can work anywhere at their convenience. Educators can view the work and post comments after reviewing students' work. Course Leaders can work with team members while constructing teaching materials and artifacts.</td>
</tr>
<tr>
<td>Google Forms</td>
<td>Educators can post forms seeking feedback on learning materials and instructional design documents with their team. Greater participation and ownership can be instilled in the educators, instruction design team and learners while working on projects or with the students if you have a digital classroom.</td>
</tr>
<tr>
<td>Wordpress and EduBlogs</td>
<td>Blogs encourage creativity, passion for unearthing knowledge of a domain which is the focus of the course. Learning is not confined to fact finding or consuming theories. Intermediate and Advanced learners will be able to build a log that contains links to interesting websites to stimulate discussions. Blogs are informal forms of learning but encourage out of the box of thinking which the basic foundation of innovation.</td>
</tr>
<tr>
<td>WikiSpaces</td>
<td>Supports multi-user document editing. Educators can design projects where the project teams' objectives, work plans, schedules, methodologies, ideas etc. This is a great place for group or classroom projects because multiple users can edit documents. Or, use it to build an educational wiki full of quality websites and reference materials for your students.</td>
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<table>
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<tr>
<th>Work Organization and Recording</th>
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<td>Evernote</td>
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<td>Dropbox</td>
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<th>Creativity</th>
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<tr>
<td>Cacoo</td>
</tr>
<tr>
<td>Bounceapp</td>
</tr>
<tr>
<td>Vyew</td>
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<tr>
<td>Bubbl.us</td>
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</tbody>
</table>
INSTRUCTIONAL DESIGN MODELS

The instruction Design Models mentioned below are:

- Seels and Glasgow (1998) credit the U.S. Air Force model, for initiating the integration of technology in instructional design it was used primarily for imparting military courses to the personnel working at different units in the US military in a systematic way that could also speed instruction process through use of appropriate technology.
- Reiser and Dick model (1996)- describe this step as the “physical means by which instruction is delivered to students”.

- The ASSURE (Heinich et al., 2002; Shelly et al., 2006). The ASSURE model is an ISD (Instructional Systems Design) process that was modified to be used by teachers in the regular classroom. The ASSURE model incorporates Robert Gagne’s events of instruction to assure effective use of media in instruction.

In Figure 7, 8 and 9 the popular models for ISD design are illustrated. For the discussion we will choose these models which are designed for traditional classroom teaching but they incorporate instruction using technology and multimedia artifacts. In the Reisner & Dick model and the ASSURE model focus
Instructional Design Technology in Higher Education System

Figure 7. Reisner and Dick Model

Figure 8. ASSURE model

Figure 9. Dick and Carey model

is on selecting learning objectives and instructional media for teaching. In the Dick and Carey Model the focus is on ascertaining the learner abilities and entry requirements before attempting the course.

There is focus on Summative and Formative evaluation to ascertain the learning achievements of the student, to evaluate the course in totality to ascertain the strengths and drawbacks of the learning content and instruction delivered. The model advocates the development of an instructional strategy for learning and assessment.

Teacher Decision making model, proposes “ADDIE process (Analysis, Design, Develop, Implement, and Evaluate) and the Kemp model”. For example, ADDIE, Dick and Carey, and Rapid Prototyping are heavily influenced by software development methodologies (Rawsthorne, 2005). ADDIE is an Instructional Systems Design (ISD) model. Most current ISD models are variations of the ADDIE process. Other models include the Dick & Carey and Kemp ISD models. Rapid prototyping is a commonly accepted improvement to this model.
IMPACT OF TECHNOLOGY ON INSTRUCTION DESIGN

The impact of technology is clear in the following phases of Instruction design. Reigeluth (1983) suggested three learning strategies (organizational, delivery and management) in Instructional Design (see Table 3).

1. Instructional material to be organized into modules and lesson plans. These need to be broken into units/structures with proper sequencing. Wiley, D.A. (2000). These units may be lecture material, task material, practical sessions material, activities and assessment material which are then broken

Table 3. Strategies for instructional design for higher education

<table>
<thead>
<tr>
<th>Strategies</th>
<th>Characteristics</th>
<th>Advantage</th>
<th>Disadvantage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Action Learning</td>
<td>Kurt Lewin in the 1940s (Weisbord, 1987)[4]. Learner groups with diverse backgrounds will be split into project teams that will investigate complex structural or management level problems to test their competency level based on the knowledge acquired prior to the project. Once the project is completed a skilled instructor will gauge their learning levels through discussions and analysis of results.</td>
<td>Skill application and review of experiences</td>
<td>It cannot be applied to all scenarios of learning</td>
</tr>
<tr>
<td>Fishbowls</td>
<td>Peer evaluation and feedback is the goal of this method of instruction design. A group of learners are broken into teams. These teams take alternate roles in assessing and evaluating each other. This is a powerful of instilling communication skills, knowledge and usage of key technical terms and acronyms, critical thinking and evaluation skills. Learners have to observe group member behavior or content of the discussion</td>
<td>Presentation and critical thinking skills are developed.</td>
<td>Suitable for limited learning contexts</td>
</tr>
<tr>
<td>Bootcamp</td>
<td>Limited Class Size (less than 12) Attendees filtered by their knowledge level in the subject. Classes are of very short duration (2 to 3 weeks) Intensity of learning is almost same. Instructions are less in number and easy to manage. Skilled Instructors help in dealing with learners who require assistance.</td>
<td>Accelerates the pace of learning. From a learner’s point of view, boot camps are highly social in nature.</td>
<td>May not be suitable for all types of learners as it cannot accommodate learning styles and preferences.</td>
</tr>
<tr>
<td>Personalized System of Instruction</td>
<td>Modular learning wherein chapters are divided into units with clear instructions for the learners that they can complete at their own pace. A learner’s progress to the next module is controlled through a module test in which the learners must attain a very high score. Learners are supported by dedicated staff as they work on tasks at their own pace. PSI combines mastery learning with principles of reinforcement learning theory. The modules must have fixed learning objectives.</td>
<td>Learner friendly instructions Learner centric tasks Assessments completed at the pace required by the learner.</td>
<td>Knowledge acquired may deteriorate unless practiced at the workplace</td>
</tr>
<tr>
<td>Programmed Learning or Branched Programming</td>
<td>Incremental learning each subsequent module is presented on the basis of performance in the previous module Correct learner responses are rewarded and incorrect responses are corrected immediately with feedback</td>
<td>Learners are given feedback so it helps the learner.</td>
<td>All learners are not suitable for this type of learning.</td>
</tr>
</tbody>
</table>
Instructional Design Technology in Higher Education System


2. Formative evaluation and auditing of these units need to be done to ascertain the match between the intended learning outcome and perceived learning outcomes of each unit. A team of domain experts will determine this and the pilot tests need to be carried out by instructors on small classes to ascertain how many learning units actually qualify to be used, the satisfaction level of students will perusing these units. The module assessment (Prakash & Saini, 2012) results will need to be evaluated with the intended learning outcomes to extract the impact of the learning materials on the learning achievement of the learners.

3. These instructional digital units are to be stored in central, shareable learning repositories (Lehman, 2007). These repositories can assist instructional designers, subject experts, and digital technology experts to work as teams to improve the units in terms of maintaining updateable, reusable, instructional units which are easily shareable across institutions or repositories (Wiley, 2002). There are issues in sharing learning resources and some frameworks have been designed to support seamless sharing of learning units in spite of challenges in sharing copyrights (Cervone, 2012).

4. The modules need to be delivered to learners from the institutions via platforms such as Web based Learning management systems, mobile applications, digital classrooms, video conferencing. Educational institutions and knowledge banks store and disseminate their data by following standards like IEEE LOM, ADL SCORM, or IMS to name just a few. Based on the delivery methods the learning platform might be suitable for classroom learning, eLearning, mLearning, Social Learning etc. However the interchange of educational content between servers or peers is still a problem which has not been solved satisfactorily. (Prakash, Saini, & Kutti, 2009).

5. Delivery strategies are concerned with the decisions that affect the way in which information is transferred to the learners. Delivery is the means of communicating and transferring a learning process to the learners. For example, you can deliver a lesson in the classroom or via e-learning (Rosenberg, 2001). This is similar to the concept of media. Some methods of delivery are: Web-based learning, self-paced learning modules, lab exercises, project based learning through tasks and group work.

6. Management strategies involve the decisions that help the learners interact with the learning activities in order that they may increase their knowledge and skills. Some of the strategies are: programmed learning (Terry and Hermanson, 1970). A strategic model is proposed for HEIs course delivery in Figure 10.

COMPUTER BASED INSTRUCTION AND INSTRUCTION DESIGN

Computing machines are used for designing instruction and they are programed for instructions. There are four major steps in designing computer based instruction which are well accepted in education system. Computer hardware, software, Psychology of the learner and interpretations are the major steps in steps of computer based instruction design. (Venezky & Osin, 1991).
Instructional design projects initially in last 60’s were based mainframe computers and most of the mainframes were funded by education ministries or governments (Alessi & Trollip, 2001; İpek, 2001). University of Illinois is the pioneer in the field of CBI because the PLATO project at the University of Illinois in 1960 was the first project which was used in instructional design process.

Slowly there was need to build Intelligent CBI rather than conventional CBI (Venezky & Osin, 1991). In the field of computer-based instruction, personal computers were first used to support education for individual learners in the 1980s, World Wide Web (WWW) technologies were first used to support e-learners in the 1990s, and mobile devices and wireless technologies were first used to support education for mobile learners in the 2000s. In general, CBI is the process of instruction, as instructional computer programs are defined by a variety of names, as follows: computer–assisted/aided instruction (CAI), computer-based education (CBE), computer-assisted learning (CAL), instructional applications of computers (IAC) and computer-based instruction (CBI).

The term ‘CBI’ pays emphasis on instruction rather than education, and because education is also a broad term. According to this approach, instructional methodologies for effective instruction should cover four phases in presenting information, guiding the student, enabling practice by the student and assessing student learning (Alessi & Trollip, 2001; İpek, 2001).

In the cognitive corner of the triangle, there are many educators and instructional designers, including Rieber (1992), Reigeluth (1996) and Jacobson and Spiro (1995), who have considered how instructional processes should depend on goals, learners and content.
Instructional Design Technology

The Figure 11 illustrates the zones of influence that need to be effectively monitored using technology driven learning environments, as a large number of actors and stakeholders are impacted by the activities performed by each actor. The field of Instructional Design Technology supports learner creativity in that learner can download and access tasks, instructional material, videos and slideshows or audios to assimilate a particular topic or topic set. In this way the learners can select mode/modes of learning which in turn provides flexibility in creation of knowledge gleaned from the material accessed.

A web-based learning system must include the following parameters as shown in Table 4.

**IMPORTANCE OF INSTRUCTIONAL DESIGN IN MODERN INSTITUTIONS IN DEVELOPING A CREATIVE LEARNING ENVIRONMENT**

The study requires that module instructors and cohorts conduct a pre – evaluation of their course profiles through a vigorous and in-depth analysis (see Figure 12) of several points in a check list. The case we discuss here pertains to that of the curriculum developmental program undertaken at a local private university in Oman. Sohar University has a separate Teaching and Learning Committee at the University level, where representatives from each of the faculties present views about various scenarios in their faculties. Figure 8 illustrates the assessment framework for the institution. It ensures that all programs are appropriate and supported by appropriate quality audit checks.

The institution follows a bottom – up approach in deciding assessment policies and mechanisms. These assessments are further matched with the Program Outcomes (POs) and Learning Objectives (LOs) (Table 5 and 6) in each program and course, respectively. The institutional goals to improve instruction design are mirrored in the figures shown above.

Every Program or specialization has to satisfy a select number of parameters, these parameters are requisites that need to be met if the program is to be approved during audit checks conducted by the government auditing bodies and international auditing bodies. Effective use of automated designs in the Instruction design tool can help incorporate sufficient efficacy while creating bodies of knowledge.
Instructional Design Technology in Higher Education System

Table 4. The web-based learning system must include the following parameters

<table>
<thead>
<tr>
<th>Structures to support learner requirements and inclinations in terms of learning styles and assessment methods.</th>
<th>Learning structures need to be customized to support various languages and communications gateways. LCMs, CMS and Web – based LMS are all integrated with language settings however learner preferences need to be gleaned by better tools settings.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Online and offline communication between tutor and learner, between learners and learner groups</td>
<td>Forums, chat sessions, recorded and logged interaction sessions between tutor and learner/learner groups, news forums and other modes of dynamic interaction must be encouraged.</td>
</tr>
<tr>
<td>Carefully planned activities and tasks to support the learning process</td>
<td>Learners must be able to relate quickly to the tasks designed and assessment methods. The task designed must not create a barrier between the learning system and the learner due to cultural or lingual differences.</td>
</tr>
<tr>
<td>Resource creation and sharing (Lakshmi, 2010 November)</td>
<td>Instructors and learners need to foster a culture of sharing perspectives on the topics discussed. Learners must be encouraged to supplement their learning experiences by sharing their views and perceptions with their peers so as to be able to formulate holistic learning experiences.</td>
</tr>
<tr>
<td>Customizable delivery modes and assessment modes must be customizable in that</td>
<td>Options must be made available in the learning structure to allow for selection of learning paths, several delivery modes and assessment methods.</td>
</tr>
<tr>
<td>Support timely instruction and feedback</td>
<td>Instructors and tutors must be able to provide timely instructions and the proactive nature of these designs will guide instructors to predict and plan how to plan for the problem before it starts.</td>
</tr>
<tr>
<td>Peer–learning and project based tasks</td>
<td>Learning activities and tasks must be designed to incorporate sharing and dissemination of knowledge and these experiences should be incorporated in the learning system for future learners. Project and case based learning instills learnt concepts and helps learners to acquire requisite skills to complete the course successfully.</td>
</tr>
<tr>
<td>Clear feedback on milestones and progression</td>
<td>Course outline and clear communication of aims, objectives and requirements</td>
</tr>
</tbody>
</table>

and/or instruction in instructional units. The selection of topics from the domain to assembling them to resurrect their match to a particular program objective can be a daunting task especially since domain knowledge can be quite vast and varied. The challenge to the instructor is in selecting topics from knowledge sets of the domain that match the context of the users learning experience and preference.

Learning modules can be assembled into learning paths using appropriate instructional toolkits and platforms like Moodle, Sakai and others.

Assessment regulations, policies and procedures (see Figure 13) are clear, comprehensive, fair, transparent, readily accessible and effectively communicated to students and staff. The assessments are based on the tasks and activities planned by instructors using appropriate learning platforms, these tasks are

Figure 12. Assessment process – characteristics
scaffolded into the learning units that further support the learner to explore topics stipulated in his learning path. E-assessment and project works are mandatory modes of knowledge validation in these systems.

The course is evaluated by the students in a post summative evaluation survey (see Figure 14) where they score the students on a scale of 1 to 4. The evaluation results are analyzed for all courses based on the scores. The results provide a mechanism for staff and higher administration to perceive the strengths of the instructional material, the adequacy of the instructional design for the course or need for reengineering the design of the course.

These mechanisms supported by other standardized accreditation procedures like ACS accreditation and local Oman accreditation Council have made the system robust and in

Benchmarking and checking validity of assessment methods. The implementation of these assessment processes are monitored to provide valid, reliable and effective academic standards. Internal and external moderation of the major components of the instructional materials, assessment components, and course and program review mechanisms are integral to the instructional design process. Review of student’s feedback is also integral to the Instruction Design process. A comprehensive review of all mechanisms and processes are integral to the Higher Education process.

Table 5. Domain matrix for each of the program outcomes

<table>
<thead>
<tr>
<th>POs</th>
<th>Knowledge</th>
<th>Practical Skills</th>
<th>Social Skill and Responsibilities</th>
<th>Values, Attitude, and Professionalism</th>
<th>Communication, Leadership, and Team Skills</th>
<th>Problem Solving and Scientific Skills</th>
<th>Information Management and Lifelong Learning Skills</th>
<th>Managerial and Entrepreneurial Skills</th>
</tr>
</thead>
<tbody>
<tr>
<td>PO1</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PO2</td>
<td>X</td>
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<td></td>
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<td></td>
<td></td>
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<tr>
<td>PO3</td>
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<td>PO8</td>
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</table>

Table 6. Domain matrix for each of the program outcomes

<table>
<thead>
<tr>
<th>No.</th>
<th>Assessment</th>
<th>Weight</th>
<th>LO1</th>
<th>LO2</th>
<th>LO3</th>
<th>LO4</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1</td>
<td>Final Exam</td>
<td>50</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>A2</td>
<td>Mid-term Test</td>
<td>20</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>A3</td>
<td>Practical &amp; Quiz</td>
<td>20</td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>A4</td>
<td>Assignment</td>
<td>10</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
CONCLUSION

Instructional Design technology requires that the instruction environment is scaffolded with sufficient technological to incorporate visualization of knowledge body, sharing of knowledge nuggets and experiences while acquiring them, inclusion of communication channels that speed up learning acquisition, peer support and advice.

The chapter is a study of cross-section of popular learning technologies, their impact and tries to predict their importance. Further a comparison is be made between Instructional design and learning design technologies. In the chapter following research finding and outcomes related to instruction design is proposed

- How to ascertain the judicious of technology for a particular instructional module.
How to incorporate a framework using components of Instructional technology where in the instructor can ascertain the instructional material do satisfy the learning outcomes of a course or program. Model formulation to analyze major assessments Practices.

Ascertain at an earlier stage any drawbacks or gaps in the designed materials.

Challenges in applying technology in every component of an assessment.

Pedagogical content knowledge transfer issues with integration of web 3.0 tools are one of the emerging areas in instruction design. Learning objectives synchronization with program outcomes and instructions design accordingly is one of the challenging tasks. Identifying the appropriate medium for instruction delivery is also having issues need to be addressed like course profile creation, content mapping process with course profile content management tools and discussion forms.

Figure 14. Course review form to evaluate the instructional design
Social media influence is also one of the emerging areas of concerns while designing instructions. Personalization of learning process is also posing a big challenge in designing the effective instruction design. In today’s environment educational media environment are changing toward Social Media era and it is affecting the instruction and delivery process in education system.

Flow, real time information networking, exploration, explanations, elaborations, engagements and evaluation of learning process are some of the issues that are to be addressed while designing instructions. Creating course profiles with scoring rubrics and effective and easier means for instructors to design and assess group projects are some of the issues which need to be considered while designing the instructions. Several steps of instructional design, assembly and delivery have been automated through several toolkits and architectures ranging from client-server networking models to cloud based models. Creation and storage of learning units are facing several challenges as the interoperability of units designed on different platforms need to conform to platform requirements of contemporary learning management systems.

REFERENCES


Instructional Design Technology in Higher Education System


**KEY TERMS AND DEFINITIONS**

- **Contextual Learning**: Building own memory, experience and response of the learner.
- **Contextualization**: Teaching and learning squarely on concrete applications with specific learner context.
- **Creativity**: Perceive the world in new way to discover or invent new patterns in the domain.
- **Instruction Design**: The acquisition of knowledge and skill required for creating instruction.
Personalized Learning: Constructing pedagogy, curriculum by learners for learners.
Ubiquitous Learning: Learning anywhere, anytime closely related with mobile technologies.
Virtual Field Trips: Exploration and collection of pre-screened, thematically based web tools for learning.
Chapter 18

Developing Creative Problem Solvers and Professional Identity through ICT in Higher Education

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ABSTRACT

This chapter regards creative problem solving as a professional identity skill that can be fostered by creative learning environments supported by Information and Communication Technology (ICT). A systematic literature review will be provided in order to build relationships between creative problem solving, creative learning environments, ICT, and professional identity in the context of higher education. The literature review will focus on the following research questions: How do ICTs support a creative learning environment in fostering creative problem solving skills? How do ICTs relate to or affect the characteristics of professional identity in the context of higher education? How do ICTs relate to or affect the formation of professional identity in the context of higher education? These three questions will help allow to organize the structure of this chapter that drive the authors to propose a change of perspective in the study of professional identity and ICT, from the theoretical standpoint of actor-network theory. Accordingly, the conclusion of this chapter contributes to implications of improvement for the better development of creative education by ICT and professional identity in the future.

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INTRODUCTION

In the current era of information and knowledge societies, information and communication technology (ICT) plays a major role in the shaping of professions, disciplines and higher education. For instance, the pedagogical use of ICT is a major theme of educational research and practice, and the professional identity of nurses and student nurses is heavily affected by the introduction of technology in hospitals and clinics. Understanding the relationships among higher education, professions and ICT is paramount in higher education institutions; these relationships are transforming at an increasing rate to keep up with the decline of the technology obsolescence period. Educational technologists advocate that technology-mediated learning practices can enhance the opportunities and outcomes of learning and contribute to achieving different attributes of a professional identity.

For students of higher education, the acquisition of applicable knowledge and ICT-integrated creative problem-solving skills specific to their future professions and disciplines is central to the development of their professional identities. The development of professional identity is a challenge in higher education due to the various pressures educational institutions face to produce graduates that have not only mastered theoretical concepts and abstractions but also know how to apply their knowledge in real life professional practices. To address this challenge, pedagogical methodologies and methods are adopted, and ICTs are integrated into the teaching-learning process. For instance, practice-based pedagogies contribute to professional identity development and prepare graduates for their future work lives (Trede, Macklin, & Bridges, 2012). The study of professional identity has been among the prominent and recurring themes of educational research, especially since the late 20th century (Bauman, 2004; Lawler, 2014). This line of research deals with two broad themes or questions: (1) what are the characteristics of a professional identity? And 2) how is a professional identity formed (Zinn & Goldsby, 2014)?

A review of the current literature is needed to understand the theoretical frameworks of creative problem solving, professional identity and ICT in higher education, as well as to explore the themes and understandings within these areas. The objective of this literature review is to investigate the relationships among creative problem solving, ICT and the professional identities of students in higher education. This objective will be addressed by applying the following three questions to the existing literature dealing with ICT and professional identity:

- How do ICTs support a creative learning environment to foster creative problem solving skills?
- How do ICTs relate to or affect the characteristics of professional identity in the context of higher education?
- How do ICTs relate to or affect the formation of students’ professional identity in the context of higher education?

These research questions will be addressed by a structured, systematic literature review in which meta-analysis, qualitative analysis and synthesis will be used. The relationships between creative problem solving skills, ICTs and professional identity will be explored through the four sections of the present chapter. First, points of departure will be identified by presenting definitions, characteristics and approaches to the development of professional identity and by emphasising creative problem solving skills and the varying intensity of ICT integration in different professions as an important part of student professional identity in higher education. Second, the systematic literature review’s methodology will be explained. Third, an analysis will be provided, including an overview of the selected literature, a
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brief meta-analysis and qualitative analysis and synthesis to address each of the three research questions outlined above. The fourth and concluding section will discuss suggested directions for future research.

BACKGROUND AND DEFINITIONS

This section provides an overview of some of the main discussions, concepts and definitions that form the background of this chapter.

Creative Problem Solving as Part of a Professional Identity

The term *information and knowledge society*, as used in the introduction, may be evidence of an outdated line of thinking. In fact, more than 10 years ago, Resnick (2002) objected against the term, arguing that the term *creative society* should be used instead. His argument follows a historical frame: during the 1980s, the shift from *industrial society* to *information society* was much debated as an expression of a new era in which the control of natural resources and manufacturing was no longer the driving force of societies. During the 1990s, it became evident that information in itself did not bring about change and development; rather, it was the application and transformation of information into knowledge that drove society forward, thus giving rise to the term *knowledge society*. Resnick acknowledges that this was an improvement, but suggests that from a future perspective, the ability to act and think creatively will determine levels of success, thus forming a *creative society* (Resnick, 2002). More recently, Gauntlett (2011) too expressed ideas regarding a creative society.

Accepting the premise of a move from a knowledge society to a creative one as suggested by Resnick and Gauntlett (2002; 2011) increases the need to instil creative problem solving skills among society’s citizens. As Gauntlett points out, historically, the educational needs of society have been institutionalised in schools and educational institutions, thus creating a context for the transfer of knowledge from teacher to student. Since the 1960s and 1970s, however, innovations within research in pedagogy and psychology have changed the understanding of learning. With Piaget and Vygotsky (Piaget, 1968; Vygotsky, 1980) as sources of inspiration, scholars and practitioners have come to acknowledge learners’ active constructions of understanding through exploration and discussion (Resnick, 2002). Craft (2005) emphasises creativity as the key to this collaborative construction of knowledge and skill, further underlining the importance of developing creative problem solving skills in education today. These developments within society and education contribute to the perception of creative problem solving skills as fundamental competences of professions and disciplines. Thus, the construction of creative learning environments that foster creative problem solving is among the most vital tasks of modern education.

Characteristics of Professional Identity

Drawing from the works of Benbasat and Zmud (2003) and Denning (2001), Zinn and Goldsby (2014) concluded that the identity of a profession can be characterised by six attributes: (1) artefact, (2) definition, (3) body of principles (conceptual knowledge), (4) body of practices (embodied knowledge, including competence), (5) professional responsibility (standards for competence, ethics and practice) and (6) durability (a durable domain of human concern). An artefact is defined as a focal object that defines the field and its immediate nomological net. In the information system (IS) discipline, Benbasat and Zmud
(2003) define the information technology (IT) system as the focal object and the practices, capabilities, usage and impact related to the system as part of the immediate nomological net. The absence of consensus about an artefact for a profession or discipline leads to an absence of an agreed-upon definition, which is the second attribute. Such a lack of consensus, whether for the artefact or the definition, is a barrier to understanding the characteristics of a professional identity. Furthermore, a body of principles that is essential and universally applicable characterises a professional identity. A body of principles consists of concepts and relations of concepts fundamental to the definition to a degree that, without mastery of which, a professional would not be successful; indeed, would not be defined as a professional at all. The body of practices determines how the body of principles is applied and how they function within a discipline. The two criteria—the body of practices and professional responsibility—are formed and transformed by certificate bodies, individual firms or trade organisations. Rules are also established through government regulations. Last, durability deals with the question: will each profession stand the test of time by continuously addressing human concerns? Thus, suggesting a certain degree of stability as defining for the professions.

Information and Communication Technologies

Information and communication technology (ICT) is an umbrella term often used as an extended synonym for IT. ICTs include communication devices and applications, both hardware and software. In professions and disciplines, ICT is a significant actor that delineates what should be included in the policy, research and practice of a profession (Denning, 2001). Cradler et al. (2002) suggest that the mastering of ICT skills is fundamental to preparing students for their work lives, and as such might be perceived as a partial component in the body of practices. Denning further urges computer scientists to define IT as an inseparable component of professions rather than as a separate discipline. Denning claims that every profession currently involves IT, but varies in the degree of IT adoption and divides IT professions into three categories: IT-specific disciplines, IT-intensive disciplines and IT-supportive disciplines. Thus, to achieve the desired level of professional identity development within higher educational institutions, the facilitation required to gain the skills and competences needed to utilise ICT as an artefact depends on the category of the ICT-involved (i.e. specific, intensive or supportive) discipline. Moreover, considering the different types of students in varied learning environments, various types of ICTs have been adopted to instil the desired knowledge and skills related to ICT as an artefact of a profession. Thus, ICT is adopted as a mediating tool for learning.

Formation of Professional Identity

Trede, Macklin and Bridges (2012) describe how practice-based pedagogies, which contribute to professional identity development, are developed to prepare graduates for their future work lives. Competencies gained from this preparation include ‘learning professional roles, understanding workplace cultures, commencing the professional socialisation process and educating towards citizenship’ (Trede et al., 2012, p. 365). The viewpoints presented by Trede, Macklin and Bridges are of a socio-cultural perspective, wherein the development of a professional identity is an ongoing process that is social in nature and negotiated in communities of practice (Wenger, 2000).

The understanding of professional identity formation that serves as the basis for this chapter has been taken from the work of Rodgers and Scott (2008). Based on the vast amount of literature on teacher
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development (specifically) and adult development (in general), Rodgers and Scott (2008) defined four basic assumptions regarding the formation and nature of identity, namely:

1. That identity is dependent upon and formed within multiple contexts, which bring social, cultural, political and historical forces to bear upon that formation
2. That identity is formed in relationship with others and involves emotions
3. That identity is shifting, unstable and multiple
4. That identity involves the construction and reconstruction of meaning through stories over time (Rodgers & Scott, 2008, p. 733)

These assumptions are supported by, among others, the works of Nyström (2008), Dehing (2013) and Johnson et al. (2012). These works refer to the contextual, relational, changeable and constructive aspects of identity (Rodgers & Scott, 2008), though some cases employ slightly different wording. First, the contextual nature of identity is elaborated by establishing how the contexts in which we are emerged shape how we perceive ourselves and how we are perceived by others, though these perceptions are not necessarily obvious or explicit to us. As such, our contexts become normative and, to a high degree, are determined and shaped by those in authority who expect compliance with set standards (including the standards regarding the choice and use of ICT). Second, the relational and emotional aspects of identity are defined as the relationships we form with others in different contexts as essential to our identity; as explained by Rodgers and Scott, ‘to have an identity one must be recognised as a particular “kind of person” by others’ (2014, p. 735). From an ICT perspective, this relates to the act of self-profiling when using different kinds of online (social) media. Third, identity is not a fixed attribute but a relational phenomenon. It must be seen as shifting and multiple. Thus, identity is a product of the connections and relationships we have at an exact moment. It is not only how we profile ourselves across different media but also whom we connect with. Fourth, with the contextual, relational and multiple nature of identity in mind, as described in the first three assumptions, Rodgers and Scott (2014) turn to the problem of how to make sense of the complex construction called identity, and point to stories to find the solution. Here, possible methodical choices in the study of identity development are indicated

LITERATURE REVIEW METHODOLOGY

This chapter investigates how the non-human actor, ICT, contributes to the characteristics of professional identity and the formation of higher education students’ professional identities, including their creative problem solving skills. As previously mentioned, the present analysis attempts to answer the following three research questions:

- How do ICTs support a creative learning environment to foster creative problem solving skills?
- How do ICTs relate to or affect the characteristics of professional identity in the context of higher education?
- How do ICTs relate to or affect the formation of professional identity in the context of higher education?
To answer the first question, a brief literature review that aims to establish the significance of ICT in developing creative learning environments and its relationships with creative problem solvers and professional identity was explored. To address the second and third questions, the methods of meta-analysis, qualitative analysis and synthesis were used, through which the presented theoretical frameworks were applied to 22 reviewed papers. An answer to the second question (concerning the characteristics of professional identity) was attempted using the six characteristics of professional identity (Zinn & Goldsby, 2014) as the thematic framework for the analysis. The authors of the present review adapted Denning’s three categories of disciplines in relation to IT (ICT-specific, ICT-intensive and IT-supportive) as part of the thematic framework. By combining these theoretical perspectives, an analytical framework was devised to illuminate the relation of ICT to the characteristics of the professions and disciplines in the reviewed papers. To answer the third question, the reviewed papers were analysed using the four assumptions regarding the formation of professional identity as presented by Rodgers and Scott (2008).

The systematic literature review regarding the second and third questions was conducted by strictly adhering to the ‘5 W’s’ search strategy developed by Zins (2000) and the PRISMA statement for reporting systematic reviews (Liberati et al., 2009). Zins describes five successive phases with seven underlying guidelines to ensure a comprehensive search that is iterative in nature and accumulates knowledge throughout the search process. The search phase was about identifying peer-reviewed and full-text articles within the area of interest (i.e. ICT and professional identity development in higher education, not limited to a specific time frame). A range of databases was chosen to ensure complete coverage of the cross-disciplinary nature of the area of interest. These databases included Web of Science, EBSCO HOST, Ebrary, Google Scholar, Psycinfo and Proquest, and searches used the following combinations of keywords and synonyms: ‘ICT, online, technology-mediated’; ‘professional identity’; ‘higher education, further education, tertiary education’. The search methods included publications’ titles, abstracts and full-text, depending on and adapted to search engine features available in the databases. Where possible, the search was limited to the titles and abstracts of peer-reviewed, full-text publications, thus narrowing the search to show only the most relevant results.

The method involving searching, screening, assessing for eligibility and exclusion is illustrated Figure 1, which is based on the PRISMA flow diagram (Liberati et al., 2009). The flowchart shows four stages: identification, screening, eligibility and inclusion. In the identification stage, the searches in databases resulted in 87 articles. In the screening stage, 17 duplicates were removed, and 17 articles were excluded after screening the titles, abstracts and keywords. Three main exclusion criteria were applied at the screening stage: 1) the publication was not available in English; 2) the publication was not peer-reviewed and 3) insufficient focus on ICT, higher education and professional identity development was noted (e.g. ICT was only used for data collection). Some of the publications dealt with the changes in identity for the lecturer in higher education as a result of teaching using ICTs. These publications were discarded, as the current study’s focus was on the professional identity of students in higher education. In the eligibility stage, 53 full-text articles were assessed for eligibility; 31 were excluded due to insufficient focus on the aspects required for this study. In both the screening and eligibility stages, the same exclusion criteria were applied. In the end, 22 articles remained to be included in the qualitative synthesis and meta-analysis.

There were obstacles involved in this systematic review, particularly due to the inherent challenges associated with the methodology of the inclusion and exclusion of articles. The authors of this chapter are aware of a number of research articles on ICT-supported professional identity development in higher education, and those articles elaborate significantly on the theme of this study. However, those articles
were not returned from the database searches; this is but one of the challenges of systematic reviews as opposed to hermeneutic reviews (Boell & Cecez-Kecmanovic, 2010).

The method of analysis applied to the articles was inspired by Strauss and Corbin (1990)’s approach to Grounded Theory. The goal of this approach is to develop a systematic methodology for looking at data with the aim of generating theory. The authors of this chapter studied the publications through a repetitive practice similar to Peirce’s abductive reasoning (Peirce & Putnam, 1992). These studies were iterated in a process wherein both researchers examined all the publications until relevant and likely themes appeared.

**ANALYSIS**

This section presents a qualitative synthesis of the 22 full-text articles, including some of the variables used for meta-analysis. The analysis begins with a structured overview of the 22 publications outlined in Table 1. Of these 22 publications, 14 are journal articles, 5 have been published in conference proceedings and 3 are PhD dissertations. In Table 1, the findings of the current review are summarised in terms of author information, data, analysis and theory and contexts of identity formation concerning ICT, geography and profession or discipline. The institutional affiliations of the authors demonstrate geographical diversity, with authors present from the USA (9), Australia (6), the UK (5), Norway (1)
**Table 1. Schematic overview of the identified articles**

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Author and Year</th>
<th>Data</th>
<th>Analysis &amp; Theory</th>
<th>Context of Identity Formation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>1. ICT</td>
<td>2. Country &amp; Institution</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>3. Profession/ Discipline &amp; Stage/ Level</td>
<td></td>
</tr>
<tr>
<td>1&lt;sup&gt;st&lt;/sup&gt;</td>
<td>(Alvermann, Rezak, Mallozzi, Boatright, &amp; Jackson, 2011)</td>
<td>One (among 11 pairs of) prospective teacher’s four intervention lessons plans and emails containing reflections on those lesson plans</td>
<td>Discourse analysis</td>
<td>Online literacy course in WebCT LMS</td>
</tr>
<tr>
<td>2&lt;sup&gt;nd&lt;/sup&gt;</td>
<td>(Balatti, Haase, Henderson, &amp; Knight, 2010)</td>
<td>The online text produced by preservice teachers and their responses to survey questions. The cohort consisted of 135 preservice teachers.</td>
<td>Social capital theory</td>
<td>Online learning environment, blogs, guides</td>
</tr>
<tr>
<td>3&lt;sup&gt;rd&lt;/sup&gt;</td>
<td>(Barnes &amp; Harmes, 2009)</td>
<td>More than 300 postings by 36 students</td>
<td>Qualitative, thematic network analysis</td>
<td>Online discussion board</td>
</tr>
<tr>
<td>4&lt;sup&gt;th&lt;/sup&gt;</td>
<td>(Boulton &amp; Hramiak, 2012)</td>
<td>Case study and group interviews with 32 trainees across two institutions</td>
<td>Reflective theory and learning theory</td>
<td>Weblogs</td>
</tr>
<tr>
<td>5&lt;sup&gt;th&lt;/sup&gt;</td>
<td>(Carrington, Kervin, &amp; Ferry, 2011)</td>
<td>Comparative case study including semi-structured interviews, observations and the collection and analysis of artifacts</td>
<td>Constructivist learning theory, theme analysis</td>
<td>Online classroom simulation, ClassSim</td>
</tr>
<tr>
<td>6&lt;sup&gt;th&lt;/sup&gt;</td>
<td>(Duemer et al., 2002)</td>
<td>Transcripts of captured conversations. Supplemental data included course syllabus, class notes, and discussion questions.</td>
<td>Phenomenological approach</td>
<td>Synchronous online discussion groups, MOO</td>
</tr>
</tbody>
</table>

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Table 1. continued

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Author and Year</th>
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<th>Analysis &amp; Theory</th>
<th>Context of Identity Formation</th>
</tr>
</thead>
<tbody>
<tr>
<td>7&lt;sup&gt;th&lt;/sup&gt;</td>
<td>(Gale, Wheeler, &amp; Kelly, 2007)</td>
<td>Semistructured interviews with a small group of six students.</td>
<td>Constructivism, PBL</td>
<td>Online problem-based learning environment</td>
</tr>
<tr>
<td>8&lt;sup&gt;th&lt;/sup&gt;</td>
<td>(Hatcher, 2012)</td>
<td>Student posts on 13 online classes</td>
<td>Communities of practice</td>
<td>Online discussion</td>
</tr>
<tr>
<td>9&lt;sup&gt;th&lt;/sup&gt;</td>
<td>(Jamissen &amp; Skou, 2010)</td>
<td>Participatory observations and recordings of students' dialogue in two cycles. Fifteen students in the first cycle and eight in the second.</td>
<td>Narrativity, multimodality, and creativity</td>
<td>Digital storytelling</td>
</tr>
<tr>
<td>10&lt;sup&gt;th&lt;/sup&gt;</td>
<td>(Jao, Oztok, &amp; Zingaro, 2012)</td>
<td>Reflective journals for an academic year, interviews.</td>
<td>Socio-cultural learning theories</td>
<td>Online learning journals</td>
</tr>
<tr>
<td>11&lt;sup&gt;th&lt;/sup&gt;</td>
<td>(Kalet et al., 2007)</td>
<td>Summarised responses of 164 students for 15 of 17 survey questions with responses on a Likert scale of 1 to 5</td>
<td>Quantitative</td>
<td>Web-based professional development portfolio</td>
</tr>
<tr>
<td>12&lt;sup&gt;th&lt;/sup&gt;</td>
<td>(Kelly, Gale, Wheeler, &amp; Tucker, 2007)</td>
<td>Case studies of 6 participants (cohort of 15 students, 5 male, 10 female)</td>
<td>Socio-cultural learning theories</td>
<td>Online community of practice</td>
</tr>
<tr>
<td>13&lt;sup&gt;th&lt;/sup&gt;</td>
<td>(Lee, 2010)</td>
<td>Written dialogue from an online discussion forum, forum design, and activity reports</td>
<td>Communities of practice</td>
<td>Online discussion forum</td>
</tr>
<tr>
<td>14&lt;sup&gt;th&lt;/sup&gt;</td>
<td>(McLoughlin, Broadbent, &amp; Boyle, 2004)</td>
<td>Qualitative analysis and descriptive statistic of a total of 389 postings by 63 students</td>
<td>Communities of practice</td>
<td>Asynchronous online discussion</td>
</tr>
</tbody>
</table>

Continued on next page
and Canada (1), though the native English-speaking nations are overrepresented. ICTs in the analysed publications include, but are not limited to, blog posts, online portfolios, discussion forums and multimodal digital productions. A variety of theoretical traditions and methodologies are represented, and nearly all fall into the categories of qualitative and constructivist approaches.

In terms of profession or discipline, a majority of the publications (14 of 22) dealt with the professional identity of teachers or professionals in education. Other represented professions or disciplines included

<table>
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<tr>
<th>Sl. No.</th>
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<th>Analysis &amp; Theory</th>
<th>Context of Identity Formation</th>
</tr>
</thead>
<tbody>
<tr>
<td>15</td>
<td>(Moss &amp; Pittaway, 2013)</td>
<td>Narratives and semi-structured interviews with one student</td>
<td>Narrative inquiry methodology</td>
<td>Online university degree</td>
</tr>
<tr>
<td>16</td>
<td>(Perry, 2012)</td>
<td>Semi-structured interviews with 16 participants (9 students and 7 site supervisors)</td>
<td>Phenomenological analysis</td>
<td>Online supervision</td>
</tr>
<tr>
<td>17</td>
<td>(Price, 2013)</td>
<td>Blogs of 13 students</td>
<td>Grounded theory</td>
<td>E-portfolios</td>
</tr>
<tr>
<td>18</td>
<td>(Sutherland, Howard, &amp; Markauskaite, 2010)</td>
<td>Forum postings by 270 students</td>
<td>Quantitative, cognitivist</td>
<td>Online discussion forum</td>
</tr>
<tr>
<td>19</td>
<td>(Sutherland &amp; Markauskaite, 2012)</td>
<td>1687 forum postings of 236 students</td>
<td>The Cognitive Product x Professional Focus (CPPF)</td>
<td>Online discussion forum</td>
</tr>
<tr>
<td>20</td>
<td>(Thoroughman, Ruzicka, &amp; Widder, 2013)</td>
<td>A comparative study of 118, first-semester essays and 96 second-semester essays.</td>
<td>Constructivism</td>
<td>Online discussion forum</td>
</tr>
<tr>
<td>21</td>
<td>(Wheeler, Kelly, &amp; Gale, 2005)</td>
<td>Interviews with six students</td>
<td>Community of practice, problem-based learning</td>
<td>Online learning environment</td>
</tr>
<tr>
<td>22</td>
<td>(Yeh et al., 2008)</td>
<td>Postings and questionnaires by 16 participants</td>
<td>Discourse analysis</td>
<td>Online peer supervision group</td>
</tr>
</tbody>
</table>

* Journal Article (J), Conference paper (C), Dissertation (D)
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engineering, mental health, theology, business and fashion, health and medicine. Upon analysing the publications, it became evident that only five articles explicitly addressed the second research question as to how ICTs relate to or affect the characteristics of professional identity. The authors of the present review looked for the six characteristics described by Zinn and Goldsby (2014). The five articles that explicitly dealt with at least one characteristic of professional identity have been analysed and synthesised in the section *How does ICT relate to/affect the characteristics of professional identity?* The section is structured according to profession or discipline. This section of analysis contributes to an understanding of ICT’s relation to the characteristics of the mental health profession, the teaching profession and the cross disciplinary area consisting of business and fashion.

Most of the publications described the application of ICT for pedagogical purposes, interpreted as identity formation. In so doing, they related primarily to the illumination of the second research question and have therefore been analysed and described in the section *How does ICT relate to or affect the formation of professional identity?* By describing the pedagogical practices using ICT, these papers also contribute to an understanding of higher education in general as ICT-supportive (or perhaps ICT-supported) when applying Denning’s terminology.

**HOW DO ICTS SUPPORT A CREATIVE LEARNING ENVIRONMENT IN FOSTERING CREATIVE PROBLEM SOLVING SKILLS?**

A 2013 literature review identified the key characteristics of the environments and conditions that are most effective in promoting creative skills development. The review concluded that the characteristics fall into three broad themes: 1) the physical environment, 2) the pedagogical environment and 3) the role of partnerships beyond the school (Davies et al., 2013).

The relevance and potential of ICT in relation to these themes have been explored in various reviews and studies. For example, Loveless (2002) suggests that the potential of digital technologies in learning contexts are in part due to their specific features of provisionality, interactivity, capacity, range, speed and automatic functions, enabling users to do things that could not be done as effectively, or at all, using other tools. Similarly, Resnick (2002) emphasises certain functionalities that support creative learning environments, specifically functionalities that allows users to not only access information, but create and design (e.g. music and simulations). Thus, new technologies create learning opportunities that follow the advances within constructivist learning theories developed over the last 50 years in shaping pedagogical environments. Furthermore, Resnick (2002) argues, the development of digital technologies necessitates a change in thinking regarding where and when people learn (i.e. the physical environment) to allow the possibility of creating learning opportunities outside the normal learning contexts (e.g. through partnerships beyond the schools, like in museums or galleries) (Davies et al., 2013).

Loveless, Burton and Turvey (2006) developed a conceptual framework to describe the interaction between three elements of creative practices with ICT: creative processes (for example, using imagination, fashioning, pursuing purpose and evaluating originality and value), the features of ICT (for example, provisionality, interactivity, capacity, range, speed, automatic functions and multimodality) and ICT capability as an expression of elements of higher order thinking-finding things out, developing ideas and making things happen, exchanging and sharing information, and reviewing, modifying and evaluating work as it progresses, through a breadth of study (Loveless et al., 2006, p. 5). The conceptual framework emphasises the interconnectedness of the elements along with the wider contexts of policy and practice.
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(e.g. curriculum, pedagogies and people). Thus, it is not ICT in itself that provides the creative learning environment, but rather its context and interrelations (Loveless, 2007).

HOW DOES ICT RELATE TO OR AFFECT THE CHARACTERISTICS OF PROFESSIONAL IDENTITY?

The Mental Health Profession

Two of the reviewed papers address the mental health profession - that is, the roles of counsellors and therapists - by investigating online supervision programmes for students in training (Perry, 2012; Yeh et al., 2008). The supervision of trainees has been valued as a fundamental approach to promote personal and professional growth and counsellor competency (Yeh et al., 2008). Traditionally, face-to-face supervision has been the accepted method, but with the development of certain technologies, one-way mirrors and audio and video recordings have now been adopted (Perry, 2012). However, despite these technological developments, the predominance of face-to-face supervision persists. Perry and Yeh et al. (2012; 2008) explore the possibilities of online supervision facilitated by synchronous online video conferences (Perry) and asynchronous online support groups (Yeh et al.). Both publications place high value on a peer support aspect.

Referring to the attributes described by Zinn and Goldsby (2014), it is evident from both papers that the description of the supervision (and thus the artefact, definition and body of principles) remain the same whether supervision is conducted online or face-to-face. Supervision provides feedback and support for trainees and transmits knowledge, values and skills by experienced practitioners and peers. However, the body of practices (i.e. how the body of principles is applied and functions) changes to allow supervision that is not restricted to a certain time, place or face-to-face setting. Ethical issues related to professional responsibility might be subject to change due to the implementation of ICTs, but Perry asserts that they warrant no more nor less concern. Yeh et al. (2008) elaborate that the inherent anonymity of online support groups alleviates the obstacles of stigma and embarrassment, but underlines that distance, which is also a feature of online supervision, is supported by a contingency plan for emergency situations that require instant contact and support by a supervisor. Durability as the sixth characteristic was not explicitly addressed in the papers, but a likely conclusion could be that supervision, like the mental health profession, is not affected in any major way by the adoption of ICT because the need for supervision, training and support of student therapists (as well as clients and mental patients) will remain constant regardless of technological developments.

Perry (2012) refers to a ‘classic text’ in family therapy supervision, citing that ‘the training and supervision subsystem has become vital to the family therapy field because it transmits the field’s values, body of knowledge, professional roles and skills to the new clinician” (Liddle, Breunlin, & Schwartz, 1988, p. 4). This falls well in line with the foundations of this chapter; that the methods and technologies (e.g. ICTs) used in education affect the characteristics of the profession. Thus, the body of practices of mental health professionals might be subject to change, and therapy sessions with clients might not necessitate face-to-face contact and presence in the same room, due to the possibilities that ICTs offer. Applying Denning’s categories, the mental health profession can be characterised as an ICT-supportive discipline. Whether the technologies applied are audio recordings and one-way mirrors or online videoconferences and support groups, ICTs remain in a supportive role for the mental health professional.
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The Discipline of Business and Fashion

In her PhD dissertation, Price (2013) explores student perceptions concerning a professional online identity and the value of an e-portfolio. For students majoring in retail merchandising and fashion product development (RFPD) at Ohio University, the transition from student to professional is a source of conflict. Unlike other disciplines and professions such as teaching, engineering, law and medicine, this discipline does not have its own specific accreditation or licensure requirements. Using Zinn and Goldsby’s (2014) terminology, professional standards are not subject to regulations by governments or by trade organisations, thus necessitating students, educational institutions and the industry to continuously define their own standards for professionals. According to Price (2013), the artefact and agreed-upon definition of RFPD is the retail economy; specifically, clothing and apparel and ‘the complex relationship with the consumer in terms of the social and psychological aspects of dress’ (p. 13). The body of principles includes all the functions and interrelations of the fashion industry’s supply chain, including design, marketing and sales. Regarding the embodied knowledge and competence of the business and fashion profession, the body of practices includes the ability to set goals, evaluate personal strengths, analyse and forecast trends, work within groups, exhibit evidence of communication skills, creative and conceptual problem solving skills, work with diverse populations and demonstrate life-long learning and aesthetic understanding (Price, 2013, p. 11-13). As in the texts that discussed the mental health profession, the characteristic of durability in the business and fashion context was not mentioned; however, historical evidence validates that fashion has been a domain of human concern for thousands of years, and it seems unlikely that it will cease to be so at any time in the immediate future.

Price (2013)’s research suggests that the use of an e-portfolio is an important tool for self-representation; it is a place for the student to demonstrate professionalism. As an embodiment of competence, the e-portfolio can be characterised as part of the body of practices of the field. Furthermore, in the absence of official professional standards, e-portfolios contribute to defining the standards of knowledge in the field, providing a visible example of how things are done in the industry. Both of these aspects demonstrate the importance of maintaining an online identity (e.g. in the form of an e-portfolio), suggesting that relevant knowledge of this is essential to the professional. Therefore, concepts for online presence and knowledge of online tools might be incorporated into the core principles of the discipline (i.e. the body of principles). Furthermore, the artefact of the discipline—the supply chain of the fashion retail economy—is increasingly affected by technological developments such as the digitalisation of parts of the design and production process (e.g. prints and colouring), the incorporation of web-based customer relationship management (CRM) tools and growing portals for online shopping and marketing. When combined, these aspects lend to the characterisation of the business and fashion industry as ICT-intensive.

The Teaching Profession

Of the 22 reviewed publications, 14 deal with professionals in teaching and education (Alvermann et al., 2011; Balatti et al., 2010; Barnes & Harmes, 2009; Boulton & Hramiak, 2012; Carrington et al., 2011; Gale et al., 2007; Jao et al., 2012; Kelly et al., 2007; Lee, 2010; McLoughlin et al., 2004; Moss & Pittaway, 2013; Sutherland et al., 2010; Sutherland & Markauskaite, 2012; Wheeler et al., 2005). Of these, only two (Alvermann et al., 2011; Moss & Pittaway, 2013) touch upon the characteristics of the profession and how these are affected by the adoption of ICTs. The remaining 12 publications relate primarily to the second research question and are thus a subject of analysis in later sections.
The study by Alvermann et al. (2011) presents the case of a prospective female science teacher who participated in an online content literacy course via Web Course Tools (WebCT) that aimed to strengthen science teachers’ capabilities to ‘combine skills-based instruction (reading) with concept-based instruction (science)’ (p. 28). In the course, the prospective teacher (whose primary areas of concentration were science and math) worked with a mentor teacher specifically skilled in speech pathology. The study focused on the clinical aspects of reflective practice that manifest during periods of pre-active teaching (e.g. lesson planning) and reflective teaching (e.g. explaining and receiving feedback on the planned lessons). These reflective practices and the cross-disciplinary nature of the mentor-mentee relationship (science vs. speech pathology) highlights the possible benefits for teachers in experimenting with combining skills-based and concept-based instruction, rather than viewing skills-based instruction as irrelevant to a science teacher’s professional identity. Alvermann (2011) identifies that online content literacy is an integral part of the professional identity of science teachers.

In their analysis of a fully online teacher education course, Moss and Pittaway (2013) reflect on new challenges in teacher education and the teaching profession brought on by the perspectives of online technologies. Through a narrative approach, the authors describe a female student's experiences with an online course and how she needed to reconceptualise ‘what it meant to be a student’ (p. 1016). The narrative examined how the physical environment of the university campus and the act of sitting in a physical space with others that were engaged in the same activity do not in themselves define being a student. The classical perception indicates the need for a break with culturally embedded notions about the role of a student due to the possibilities provided by online teaching supplied by the development of technologies. The authors of the present study conclude that the increasing application of e-learning may challenge traditional notions of what it means to be a teacher. These changes suggest a broadening of the role of the teacher, necessitating ‘significant identity work’ (Moss & Pittaway, 2013, p. 1017) in the preparation and education of teachers.

To refer once more to the characteristics of Zinn and Goldsby (2014), the work by Moss and Pittaway (2013) suggests that the inclusion and application of ICTs in the teaching profession changes not only the profession’s body of practices by supplying teachers with classroom technologies, but that it might also question the artefact that defines the profession’s identity by reconceptualising the role of teacher rather than basing it on physical presence in a physical classroom. However, Moss and Pittaway (2013) do not offer suggestions as to what this new conceptualisation might be, but rather simply make the point that it requires significant identity work. The work by Alvermann et al. (2011), in contrast, illuminates the effect of ICT on the body of principles of the teaching professional’s identity, suggesting that online literacy might be added to these principles.

**HOW DOES ICT RELATE TO OR AFFECT THE FORMATION OF PROFESSIONAL IDENTITY?**

As a first assumption regarding the formation of identity, Rodgers and Scott (2008) state that identity depends on the contexts in which we emerge ourselves. This assumption is present in many of the reviewed publications, where the use of ICTs provides access to or creates a professional context (Balatti et al., 2010; Barnes & Harmes, 2009; Boulton & Hramiak, 2012; Duemer et al., 2002; Hatcher, 2012; Kelly et al., 2007; Lee, 2010; McLoughlin et al., 2004; Perry, 2012; Sutherland & Markauskaite, 2012; Yeh et al., 2008). The concept of communities of practice (Wenger, 2000) plays a significant role in
defining identity for a number of these publications. From this perspective, represented by Balatti et al., Barnes and Harmes, Duemer et al., Kelly et al. and Sutherland and Markauskaite, identity development is supported by forming and participating in communities of practice in which students share in the negation of meaning for a better understanding of the professional practice for which they are preparing. The study by Hatcher (2012) concludes that, among other things, stories shared on a discussion forum (told by both instructors and classmates with experience in first careers or pastoral ministry) built a cooperative repertoire of professional practice inherent in a community of practice (Wenger, 2000). According to Sutherland and Markauskaite (2012), a community is formed when experienced professionals cooperate to create authentic learning experiences. The discussions in the community are intended to support reflection and students’ ability to link theory and practice. This connection is also the focus of the work of Thoroughman et al. (2013), who investigated an educational activity that enables students to ‘consider novel solutions, and a content- and community-driven forum to evaluate and appreciate the real-world and social relevance of their coursework’ (Thoroughman et al., 2013, p. F1D-2). The integration of coursework (e.g. math, physics and chemistry) to ‘a real-world, current topic’ takes the form of asynchronous online discussions facilitated by an upperclassman. Similarly, an upperclassman—a graduate student mentor—served in the role of facilitator in Duemer et al. (2002)’s study. The results of this study suggest that ‘through reading and (synchronous, ed.) discussion of professional issues, students may begin to view themselves as members of the engineering profession’ (Duemer et al., 2002, p. 1).

A number of the publications examined by the current review focused on ICT’s affordance to create professional contexts by connecting users at a distance. The flexibility of ICT, as well as the independence of time and place, allows adult learners in employment and/or remote locations to access learning content at their convenience (Gale et al., 2007; Kelly et al., 2007; Moss & Pittaway, 2013; Wheeler et al., 2005). ‘Students at a distance’ was a topic discussed in other publications aimed at supporting and connecting students during internships and placements, though different terminology was applied depending on the context (Balatti et al., 2010; Barnes & Harmes, 2009; Boulton & Hramiak, 2012). In these cases, students shared content and reflected on experiences from their internships ‘to maintain a sense of community and to support and document the continued professional identity development’ (Barnes & Harmes, 2009, p. 2727). The element of peer interaction and support was also present in the works of Perry (2012) and Yeh et al. (2008). Perry (2012) emphasised the multicultural experiences of a group of students in clinical training, stating that ‘…this exposure would not be possible in their local geographic area and the online learning made it possible to add these multivariate experiences to the interns’ professional identity’ (p. 64).

To provide a second perspective, Rodgers and Scott state that identity is formed in relation to others and involves emotions. This socio-constructivist stance was a recurring theme in many of the publications. Boulton and Hramiak’s theoretical point of departure was based on a combination of reflective theories (e.g. Schön, 1984) and socio-constructivist learning theories, viewing learning as social media- tion of individual knowledge (Vygotsky, 1980). Public reflection on one’s professional identity development—such as on a personal blog—facilitates the formation of a community of reflectors, yielding benefit simply by having students read other students’ reflections. This was observed to not only scaffold a development of reflective practices for students but also expand the students’ knowledge base. Similar conclusions were drawn by Perry (2012), who observed that online supervision added a breadth and depth to the understanding of the characteristics of a profession. Yeh et al. (2008) described how the anonymity of online peer supervision groups facilitates a supportive atmosphere, leaving the participants free to express and share personal, vulnerable material.
The third and fourth assumptions were presented by Rodgers and Scott (2008), for whom identity is shifting, unstable and multiple, and involves the construction and reconstruction of meaning through stories over time. These qualities are evident in many of the publications (Alvermann et al., 2011; Jamissen & Skou, 2010; Jao et al., 2012; Kalet et al., 2007) that underline the constructive and reflective practices of students facilitated by the use of ICTs. A common view among these publications is that ICTs are used to scaffold students’ individual reflections and learning processes. Jao et al. (2012) emphasised how (in one case) student teachers began education with individual experiences and perceptions shaped by their pasts, and suggested that student teachers who keep online learning journals benefit because ‘…earlier reflections are a temporal artefact in their development as a teacher’ (Jao et al., 2012, p. 1814). Through written reflection, students have the possibility of articulating and reflecting on thoughts and ideas (Jao et al., 2012, p. 1813). Kalet et al. (2007) emphasised the importance of reflection, stating that ‘reflection translates the experience of clinical practice into learning and is a crucial intellectual task in professional competency’ (p. 1066). The focus on individual reflection made possible by ICTs was also present in work by Jamissen and Skou (2010), who discussed developing students’ abilities as reflective practitioners by producing digital stories, because ‘through stories, professionals have the opportunity to reflect on both feelings and technical aspects in clinical situations’ (p. 2).

Other publications focused on ICT’s affordance to produce content that enables reflection. This was the case in the works by Jao et al., Kalet et al. and Price (2012; 2007; 2013), for whom online professional development portfolios, online learning journals and e-portfolios provide students with a means to produce written content. The production of content (i.e. digital stories) was also the object of focus in Jamissen and Skou (2010)’s work.

Only one study used ICT to simulate a practice (Carrington et al., 2011). The purpose of the activity was to support the theory-practice link and ‘better equip pre-service teachers in the transfer of knowledge and skills acquired during their pre-service training to real life classrooms and thus contribute to their developing professional identity’ (Carrington et al., 2011, p. 355). Based on a comparative case study of 1st and 4th year student teachers, and using data including semi-structured interviews, observations and the collection and analysis of artefacts, a research team studied students’ engagements with a simulation tool, ClassSim. The inquiry highlighted a number of important design features that were relevant to the development of a professional identity as a teacher. These features include the introduction to relevant professional scenarios, link to support material providing access to relevant theories alongside the professional scenarios, and a space for reflection, as reflective activities can assist in the linking of theory and practice (Carrington et al., 2011).

Carrington et al. (2011), Sutherland et al. (2010) and Sutherland and Markauskaite (2012) all examined the role of online environments’ specific design features in supporting individual learning experiences. Sutherland and Markauskaite (2012) suggest that ‘process displays, prompts and models can remind students to engage in reflective processes’ (p. 752). In the cases of Sutherland et al. (2010) and Sutherland and Markauskaite (2012), a set of pre-specified tags, based on Bereiter and Scardamalia’s (1998) schemata of the levels of working with knowledge were added to a discussion forum to capture the typical processes in knowledge work and assist students in engaging in reflective practices. Assigning weights to the tags allowed for the examination of large cohorts of students’ social and cognitive engagement with knowledge and reflection. In their development of an online classroom simulation, Carrington et al. (2011) incorporated ‘a reflective space which was carefully scaffolded to include prompts and discussion points’ (p. 355) and that assisted the students in examining their learning and thus moving them to new understandings by re-evaluating what they already know. Sutherland et al. (2010) elaborated on the
individual student’s cognitive processes as part of developing professional identities by ‘understanding of complex practice, and ethical conduct associated with effective engagement in the complex environment of the classroom’ (p. 458). The works cited above all contribute to a knowledge base on specific design features of ICT and the relevance of these features in support of professional identity development.

**FUTURE RESEARCH DIRECTIONS**

For students of higher education, the acquisition of applicable knowledge and problem-solving skills specific to their future professions and disciplines are central to their development of professional identities. The analysis conducted in the present study indicates that problem solving skills, professional competence and identity are mediated through various ICTs adopted as part of higher education teaching-learning activities, which bring actors in the professional network into dialogue, cooperation and collaboration.

During the analysis, it became evident that the predominant socio-cultural perspective on identity among the majority of the reviewed publications holds a major consequence for the questions that this chapter set out to answer. As noted by Wenger (2000), Rodgers and Scott (2008) and Trede, Macklin and Bridges (2012), many of the publications study the ongoing process of identity development and the potential of ICTs in facilitating this process. The main contribution of these papers is thus to the development of pedagogic and didactic practices and models, following the tradition of research in Computer Supported Collaborative Learning (CSCL). This focus enabled a discussion that answered the second research question as to how ICT relates to or affects the formation of professional identity.

The first research question, which asked how ICT relates to or affects the characteristics of professional identity, proved more difficult to answer. In a number of the professions and disciplines present in the current review, this question is not even addressed. This in itself suggests that there is potential for future research in this area. Do professions and disciplines change when technologies change and develop? And how does higher education contribute to this development as an actor that is helping to delineate and shape professions and disciplines, including the role and use of technology? This area of research suggests a theoretical direction other than CSCL. The authors of this chapter propose that science and technology studies (STS) and actor-network theory (ANT) be used as valuable perspectives to approach these questions. From this perspective, ICT is not only a tool in the hands of men, but also an active participant in shaping professions and professionals. Thus, further studies that focus on theory development, methodology and empirical studies of practices are needed.

**CONCLUSION**

The purpose of this chapter was to investigate the relationship between ICT creative problem solving skills and professional identity development for students in higher education through a systematic literature review. The review supplied the answers for the chapter’s three research questions:

- How do ICTs support a creative learning environment to foster creative problem solving skills?
- How do ICTs relate to or affect the characteristics of professional identity in the context of higher education?
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- How do ICTs relate to or affect the formation of professional identity in the context of higher education?

The challenges inherent in answering these questions include a certain proclivity for socio-cultural approaches to the understanding of professional identity formation, thus leaving the interrelatedness of ICT to the characteristics of professional identity underexplored.

The analysis conducted under the present study allowed the authors to reach three significant conclusions. First, the examined publications successfully underlined the complexity of the pedagogical task of facilitating creative problem solving skills and identity development using ICT. The complex, contextual, and relational nature of professional identity is evident through the many approaches described in the publications. Second, different pedagogies and activities may be applied to facilitate the complex theoretical construct of professional identity, including but not limited to problem-based learning, simulation, reflection, documentation and evaluation. And third, the affordances of ICT and the knowledge necessary to appropriately apply and understand these affordances are subject to rapid change due to the continuous development of technology. Creating digital learning environments that facilitate creative problem solving and professional identity development in higher education is a task requiring knowledge of both the affordances of pedagogies and technologies and of the nature of professional identity.

Considering the continuous increase in the integration and adoption of ICTs in professions and educational institutions, one might argue that without clear labelling of professions according to the three categories adapted from Denning (2001) (ICT-specific, ICT-intensive and IT-supportive), it is difficult to set goals for higher education institutions about instilling professional identity. Thus, ICT is to be considered as a significant actor in shaping professional identities of the present and future.

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KEY TERMS AND DEFINITIONS

Creative Problem Solving: A process that generates new ideas or produces novel combinations of existing ideas that leads to further solutions or a deeper understanding of knowledge.

Creative Learning Environment: An environment that supports creative problem solving.

Higher Education: In this context, the term refers to all types of education above secondary education and provided by acknowledged educational institutions, i.e. universities, colleges, etc. Higher education is perceived as synonymous to further education and tertiary education.

ICT: Information and Communication Technology (ICT) is an umbrella term often used as an extended synonym for Information Technology (IT). ICTs include communication devices and applications, both hardware and software.

Professional Identity: A theoretical construct that in this publication is perceived as contextual, relational and changeable in nature.

Mental Health Profession: The mental health profession includes job titles such as therapist and psychologist. The primary aim of the profession is to provide counselling and psychotherapy to individuals, couples and families.

Systematic Literature Review: A systematic review that aims to provide an exhaustive summary of the current literature relevant to a research question.
Chapter 19

Reaching “Creating” in Bloom’s Taxonomy: The Merging of Heutagogy and Technology in Online Learning

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ABSTRACT

Creativity of thought and critical thinking are two concepts that faculty struggle with teaching in higher education, particularly in the distance learning environment. Bloom’s taxonomy has been used to define taxonomic levels in learning since the 1950’s; “create” is one of its highest taxonomic levels. It can be difficult to create relevant, authentic assessments that require students to display both synthesis of meaning, as well creative synthesis of concepts learned to reach this “create” level in an effective manner. Transformative learning and especially heutagogy or “self-determined learning” can be used as theoretical curriculum models or frameworks to help students learn and solve problems. These two theories are particularly effective when leveraged with technology. Today’s instructional technologies allow students to more readily create and explore new concepts on their own to generate a more fulfilling education process with meaningful relevant practice and assessment.

INTRODUCTION

Pedagogical practices have primarily been somewhat consistent since the mid-twentieth century. In the last two decades, there has been a significant movement towards other educational theories such as andragogy, transformative learning, emerging pedagogies and heutagogy. This movement has primarily been driving by online/distance learning and the globalization of the virtual classroom. Even before this movement, there has been significant complaint from teachers, professors and employers that students cannot think critically and lack creative problem solving skills. Continual movement to emerging pedagogies, thoughtful use of technology in an appropriate manner, problem-based curriculum and a movement towards heutagogy is one way this problem can be overcome. This can be accomplished
through appropriate curriculum mapping and alignment with appropriate assessment to ensure students can achieve learning in the evaluation and particularly creation levels of Bloom’s taxonomy.

This chapter will discuss the concepts of critical thinking, volition and creative thought within the context of traditional and emerging pedagogies in an attempt to build a case for creative and authentic educational curriculum and assessments that leverage technology. Technology can assist educators to create assessments that reach this “create” level in Bloom’s taxonomy and move the educational process from teacher-led pedagogies to self-determined learning. The intent is to serve as a basic guide for educators in how these theories and concepts can be used to promote critical thinking and creative thought in this age of technological advances in education.

CRITICAL THINKING, VOLITION AND CREATIVE PROBLEM SOLVING

Critical Thinking

What is critical thinking and creative problem solving and why do employers and faculty require them? According to the Foundation of Critical Thinking (2015), the concept of critical thinking gained relevancy in the late twentieth century although the journey truly began with the experiments of Edward Glaser in 1941. Glaser noted three major components of critical thinking: 1) being able to consider and be thoughtful about problems within the context of one’s own experience, 2) the ability to understand reasoning and logical inquiry, and 3) being able to apply concepts one and two. He notes in order to think, one must first recognize a problem exists and look for evidence to reach conclusions. In addition, one must be able to evaluate both sides of an issue, understand inherent bias, interpret data and be able to appraise and discriminate the context of the problem. This is done based on one’s experiences, beliefs, and past learning. Most importantly, one must come to conclusions and test them.

The Foundation of Critical Thinking’s formal definition stems from a presentation by Michael Scriven and Richard Paul in 1987 at the 8th Annual International Conference on Critical Thinking and Education Reform. Their definition of critical thinking is:

Critical thinking is the intellectually disciplined process of actively and skillfully conceptualizing, applying, analyzing, synthesizing, and/or evaluating information gathered from, or generated by, observation, experience, reflection, reasoning, or communication, as a guide to belief and action. In its exemplary form, it is based on universal intellectual values that transcend subject matter divisions: clarity, accuracy, precision, consistency, relevance, sound evidence, good reasons, depth, breadth, and fairness (Foundation for Critical Thinking, 2013, para 1).

Critical thinking has been present since the beginning of time. Without critical thinking, early man would never have been able to feed himself, live, progress and prosper. The Industrial Age occurred long before the concept of critical thinking was truly identified by Glaser (1941). The United States was the first country to create an atomic bomb and put man on the moon before the concept of critical thinking took root. So this poses the question: did critical thinking exist previously in the American culture and it was lost somehow within the last half a century? Or have advances in technology which have made our lives easier somehow impacted the ability to think creatively? These questions are not easily answered. There is no doubt that there are definitely pockets of critical thinkers who have been
able to create great advances. If we consider Tim Berners-Lee who created the Internet, Bill Gates the genius behind Microsoft, Melissa Mayer at Yahoo and Steve Jobs who catapulted Apple into popularity a second time after it appeared as if its time was done, there is no doubt these people possessed critical thinking skills. Were there always the “haves” and the “have-nots” in regards to critical thinking and we view our past with rose-colored classes? This is possible to a certain extent since we all have different intelligences, talents and gifts; however, inherently critical thinking is ultimately required for survival and has been since the inception of man. Is critical thinking impacted by technology of the early 21st century with its constant bombardment from social media, on-demand entertainment and the ability to search out anything we want at our fingertips rather than to know it? Or does the ready availability of information increase the potential for creative and critical thought? Things move so fast and change so rapidly, it is more difficult to discriminate the wheat from the chaff. If there is so much we can know, then what should we know? This leads to the issue of information literacy, technological literacy and metaliteracy which are embedded in critical thinking. If we cannot discern between correct and incorrect information, we do not have the true facts and issues in order to be able to think critically.

In 1990 Peter Facione published the “Delphi Report” on critical thinking. A panel of 46 experts participated in six rounds of questioning to identify characteristics of critical thinkers. The consensus of this group was the following cognitive skills are needed for critical thinking: 1) interpretation, 2) analysis, 3) evaluation, 4) inference, 5) explanation and 6) self-regulation.

According to Richard and Linda Elder (2008), critical thinkers must also be able to use and interpret abstract ideals. In addition, they must look at future impact and scenarios. They note critical thinking is self-directed, self-disciplined and requires self-correction. Of these three, self-directed is perhaps the most problematic. A common complaint of teachers, professors and employers is also a lack of self-direction and motivation in students and workers. There is a plethora of literature on motivation; however, yet we truly do not understand in many cases how and when to motivate students. Can we in fact motivate them as teachers and faculty, or are they responsible for motivating themselves? If you look to transformative learning theory, which will be discussed later on in this chapter, it is truly both

Volition

One fairly interesting concept in the field of student motivation is the concept of volition. Deimann and Bastiaens (2010) defined volition as the “ability to ward off distractions and stay focused” (p. 1). In online and distance learning, this concept is a critical one. The demographic characteristics of the average online student in the United States are Caucasian females between the ages of 25 and 29 who work full time and have a total family income of less than $40,000. Half are married and half have children; all have competing priorities (Clinefelter & Aslanian, 2014). Without volition, any online student will typically not do well in school. However, in the face-to-face classroom seeing the instructor physically may make more of an impact. Online the student is anonymous and without volition the work will not get completed. Deimann and Bastiaens believed motivation does not explain human action in the online classroom. Students can be “motivated” and interested but not accomplish tasks. Most in the teaching profession have experienced a student who is smart in class, answers questions and appears motivated and engaged yet never completes his/her assignments. Kuhl (1985) described action control strategies to balance cognitive, motivational and emotional processes. He called this as the “will as a steersman” and noted the following was needed:
Reaching “Creating” in Bloom’s Taxonomy

- Selective attention.
- Encoding control (the ability to process and discern incoming stimulus).
- Emotion control.
- Motivation control (ability to keep eye on the goal).
- Environment control.
- Parsimonious information processing (knowing when to stop and when to go forward).

In essence, these characteristics are what we commonly call maturity. These characteristics were first identified by Kuhl in 1985. At this point, computers were just starting to be found in homes and the Internet had only been invented two years previously and would not be in wide use for almost a decade. What perhaps has happened is the number of things that interfere with volition have grown exponentially and students are having even more difficulty, particularly with encoding control and parsimonious behaviors. We now live in a world where everyone wants everything now and they are not willing to settle for delayed gratification. These factors can lead to poor performance, particularly in the online environment, and has resulted on high dropout rates for many institutions.

Creative Thinking and Problem-Solving

What if a student is motivated, has volition, but has no creativity in his/her thinking processes?

To quote Zeng, Proctor and Salvendy (2011, p. 25), “Creativity is assumed to be present within every individual, although geniuses are rare.” Tanggaard (2012) notes although creativity is thought by many to be an individualized process, it cannot occur without materials. A new type of motor cannot be designed without metal fabrications. In addition, creativity must occur within the parameters of what materials exist as well as their limitations. Because creations are most often built from ideas of existing creations, Tanggaard (2012) postulates creativity is social and material as well as relational. She calls this as the sociomateriality of creativity and its collectiveness. This is particularly true in today’s world where other people’s creativity is publicized freely on the worldwide web. Creativity is “more generative” and in fact lacks newness and is often improvisational (p. 25). She notes creativity inspires movement and that is what is strived for in the classroom. As noted by McDermott (2006), “genius is cumulative” (p. 270).

From Tanggaard’s perspective, “nothing is achieved by…a teacher…developing a wonderful pedagogical concept is her/she cannot convince others and get them to invest their feelings in it” (2012, p. 26). Consequently, an instructor can create the most creative assignment in the world to get their students to reach higher levels of knowledge, but if the students do not invest in it, then it is worthless.

Mishra, Henriksen and the Deep-Play Research Group (2013) noted there is still significant conflict, particularly in education, as to how creativity should be defined. They note “the lack of a common definition prevents us from having a shared understanding of the construct” (p.11). A creative idea is novel, but novelty does not necessarily lead to feasibility. Mishra et al. (2013) note creative ideas must also be effective and whole or well-crafted.

Some researchers have noted motivation is linked to creativity (Sternberg & Lubart, 1991; Woodman & Schoenfeldt, 1990; Torrance, 1987). Thus, researchers have also concluded creative activities are meaningful (Drazin, Glynn & Kajanijan, 1999; Kaufman & Bauer, 2002). Getting the correct answer is considered convergent thinking, while finding several possible answers is considered divergent thinking (Benedek, Konen & Neubauer, 2012). Creativity often deals within the realm of divergent thinking where solutions can be theorized for problems that are poorly defined. DeHaan (2011) notes in the classroom...
too much time is spent trying to find the correct solution rather creatively finding multiple ones. He notes creativity is very complex and can be hard to evaluate. He suggests two theoretical frameworks. The first is creative insight (an “aha” moment) and the second is creativity as a social phenomenon. Fink et al. (2011) performed MRI's on a group of 24 participants to look at brain activity in relation to creativity. Exposure to common ideas stimulated the originality of produced ideas; this was visualized by increased activity in the left lateralized neural network. When exposed to original ideas, significantly increased stimulation occurred in the right parietal regions. The researchers postulated that exposure to original thinking helps the brain quickly retrieve previously learned information to evaluate the new ideas. Overall, participants were more creative when exposed to others’ ideas.

It is also important to note the perceptions we have about our own creativity that can also play into creative thinking. Hughes, Furnham and Batey (2013) administered a survey to 222 participants and had them self-rate their creativity. The researchers looked at scientific, social, visual-artistic, verbal, artistic and sports creativity. What they found was everyone rated themselves to be just slightly above average in all categories. Males tended to rate themselves slightly higher than females. However, in general, in this study and others, participants tend to think of creativity artistically rather than in regards to creative problem solving which they tend to associate with intelligence. However, it is both.

For creativity to occur, associative thinking must be present. Associative thinking differs greatly from analytical problem solving. Associative thinking links ideas that may not in fact seem to have any relation---the six degrees of separation if you will. Scott, Leritz and Mumford (2004) performed a meta-analysis on 70 creativity training studies and found creativity could be enhanced by teaching students techniques to increase associative thinking. DeHaan (2011) lists some strategies that can be used in high school and college students to increase these skills:

- **Think-Pair-Share-Create**: An instructor poses an open-ended question, students think about it individually, students pair with a partner to discuss and come up with a joint response.
- **Peer Instruction**: A question is posed and students come up with their possible answers and then have to defend their choice to their peers.
- **Think-Aloud-Pair-Problem Solving**: An instructor poses a question from topics discussed previously and breaks students into groups where one becomes the explainer and the other the questioner.

Liu, Lin, Jian and Liou (2012) examined creativity in an Introduction and Application of Media course consisting of 28 students in Taiwan. Students were allowed to pick any topic they wanted and were given choice for their midterm and final projects. Only vague guidelines were given. They found task value and self-efficacy increased significantly, as did motivation. They also assessed goal orientation, organization and critical thinking and although these were increased, they did not differ significantly from the pre-assessment. Liu et al. recommended to spur creativity and self-efficacy assignments should be fuzzy and open-ended. However, students may in fact dislike fuzzy and open-ended assignments and often ask specific questions about what is required. Is this a lack of creativity? More likely, it is a learning behavior on their parts where they were not given the freedom to explore multiple routes to the same end product and were required to confirm to the teacher’s one designated route.

In order to take students to the next step of reaching critical thinking and the highest domains of learning, it is important to consider the different theories of how we learn and what teaching methods work best. This then must be tied into the designated levels of knowledge we want students to obtain
and how to develop curriculum to ensure this happens. This is where technology can be a great benefit or a hindrance, depending upon how it is utilized.

If you link the concepts of critical thinking and creativity, there are several places in the critical thinking process where creativity is needed to enhance decision-making. In the six cognitive skills sets listed by Facione in 1990 in the “Delphi Report” (interpretation, analysis, evaluation, inference, explanation and self-regulation) creativity is an important component of several of these skill sets. According to Facione (1990), interpretation includes categorization, decoding significance and clarifying meaning. Those capable of creative thought decode and categorize data differently. They see relationships where others may not; this can lead to new thoughts and ideas. Facione notes the analysis phase includes examining ideas, identifying arguments and analyzing arguments. Those who think creatively are likely to examine alternate points of view that may be very different from the arguments that are freely evident. Inference includes conjecturing alternatives. Creative thinkers can imagine many different competing alternatives and conclusions outside the realm of pragmatic thought.

STANDARD AND EMERGING PEDAGOGIES

Pedagogy was defined as the art and science of teaching children by Knowles in 1973. Since that time, the definition has been expanded to include students through the end of secondary school. However, pedagogy really has very little to do with actual age. Rather, it has to do primarily with the context underlying the teaching process. Therefore, pedagogy can be used at any age from 1 to 100. Pedagogy is teacher-directed learning and tends to be passive in nature. The teacher delivers the information and the students memorize or absorb it through mental osmosis. The most common pedagogical theories are behaviorism, cognitivism and constructionism. Of these, behaviorism is the most passive with constructivism being the least passive. In behaviorism a student is exposed to stimuli. If he chooses to comply and learn the knowledge which was delivered in the form of stimuli (usually the teacher lecturing), he gets a positive reinforcement—he passes the test. If he chooses not to comply, he receives a negative reinforcement (a failing grade) or potentially numerous negative reinforcements (gets grounded by his parents, fails to move to the next grade, etc. etc.). It is the “carrot and stick” approach to learning.

Frankly, this approach did just did not give humans enough credit and did not allow for the complexity of our desires and emotions; nor did it consider confounding variables. However, in today’s world, these confounding variables have become even more important and evident and include such things as poverty (a student cannot perform to maximum academic capacity if he is hungry) to overuse of technology that is so readily available. Therefore, this theory fell out of favor, but this does not mean behaviorism is without benefit. It can be a very beneficial concept to understand when designing effective curriculum. It can be ascertained fairly quickly that behaviorism and creativity do not necessarily go hand-in-hand. Behaviorism requires convergent thinking, while creativity requires divergent thinking.

The next major pedagogical theory is cognitivism. Cognitivism acknowledges people think, learn and process information differently because they are all unique beings with different brain chemistry. Cognitivism and creativity can go hand-in-hand much more readily than behaviorism. The final traditional pedagogy is constructivism which basically means knowledge is constructed based on past experiences and the way students uniquely view the work. We learn through adaptation which takes cognitivism a step further. Constructivism is more likely to yield creative thought than either behaviorism or cognitivism.
Pedagogy 2.0 is an emerging pedagogy that considers the use of the Internet and technology, as well as the free availability of information. Just as students are consumers in regards to the next fall fashion or the next popular music, they are also now consumers of information. McLoughlin and Lee (2008) note the Internet has caused a blurring between academia, work and social lives; therefore, learning occurs continually. Technology is a great faculty “extender;” however, it can be just as great of a detractor. When learning becomes based around mastering a technology versus how to gain knowledge in a field of study, a “disconnect” has occurred. In addition, there is still a significant divide in technological savvy of both students and faculty, and it is not only the faculty that are lacking in needed skills. Many faculty do not feel comfortable with the rapidly changing technologies in education. Students, while avid user of social media platforms, do not necessarily know how to leverage technology to increase their productivity in either an academic or a work environment.

Since pedagogy was thought primarily to be the teaching and learning of the young, andragogy was coined to reflect the teaching needs of the adult by Knowles in 1970, because he felt pedagogy just did not explain the learning needs of this population. Andragogy is self-directed learning and is student-centered and more active.

Student-centered learning theories have become much more popular in the last several decades, even at the secondary level. This is primarily because the onus for learning truly lies on the student who has to want to learn even more than on the teachers. Students have to want to become more involved in their own learning process. Student-centered learning theories, such as andragogy, are even more compatible with creativity and enhanced creative thinking.

In addition, during the last several decades, there have been additional emerging pedagogies. This includes Jack Mezirow’s concept of transformative learning where both the teacher and the student must open up their minds to different possibilities and transform in order for optimal student learning to take place (1978, 1985, 1990, 1991, 1997, 1998, 2000, 2003, 2006). Mezirow noted transformative learning is “effecting change in a frame of reference” (1997, p. 5) which include both habits of mind and the way things are reviewed. It is moving from what a learner believes based on current experiences, adopting new meaning schemes and through reflection and learning how to critically think about an issue. It allows a student to overcome preconceptions of what she thought she knew (her potential biases) and reach critical thought where the issue or concept can be evaluated from all aspects. In this process, a learner becomes autonomous instead of passively filled with someone else’s ideas. This autonomy also can lead to creative thought through the reflective process which is a critical component of transformative learning and education. Mezirow (1997) notes in order for transformation to occur, both faculty and students must transform in their thinking processes. If one or the other does not transform, then the student learning is not effective. In transformative learning, time must be taken to participate in this reflective process to reach higher levels of learning.

Transformative learning spurs both reflective and creative thought. But perhaps the educational theory with the most potential for creative thought is heutagogy, a theory that was postulated by Hase and Kenyon in 2000.

Heutagogy is “a form of self-determined learning” (Hase & Kenyon, 2000, p. 1). Heutagogy is based on the principles of double-loop learning (Argyris & Schon, 1974) where instead of adopting a different strategy when one does not work, the learner actually examines the variables that help determine which strategy is the most effective one. In the case of learning calculus, these variables might include the time the learner is willing to spend, the applicability of calculus to his/her life and future career, etc. In essence, the ability to identify and evaluate these variables is the underpinning of both critical
thinking as well as creativity. Heutagogy is proactive, rather than reactive. It is evaluating the possible scenarios to choose the best possible outcome. In heutagogy, the teacher supplies the material and the students determine how to get to the end product. These are the characteristics employers are looking for in graduates.

Heutagogy is “knowledge sharing rather than knowledge hoarding” (Hase & Kenyon, 2001, p. 2). They further note the goal of learning is to create capable people who know how to learn on their own, are creative and can apply what they have learned in unfamiliar situations. Heutagogy is consistent with creating capable people who can adapt in unknown situations which, in essence, means they can function at the “create level” (Hase & Kenyon, 2001). Heutagogy is connected to both complexity and capability theories; a student has to be capable enough to deal with complex situations. In addition, its basis is humanism and constructivism (Hase & Kenyon, 2013).

Hase and Kenyon (2013) note heutagogy should not be the primary learning theory used in all cases. Pedagogical and andragogical approaches are necessary in order for students to progress to self-determined learning. However, these methods should be problem-based and approximate real life situations as much as possible. Hase and Kenyon (2013) note the following are required in a heutagogical approach:

- The learner should be involved in designing his own learning.
- Curriculum should be flexible to allow the exploration of new questions.
- Individualized learning is present.
- Assessment is flexible and negotiated.
- Learners need to contextualize concepts, knowledge and new understanding.
- A plethora of resources should be provided.

This idea of flexible curriculum is a difficult concept for educators today who have been using standardized and objective testing methods; it challenges current paradigms. Of course, these negotiated assessments must be within certain parameters to ensure competency in content is obtained.

Life is continually complex with open non-linear systems. A generation of linear thinkers will not be able to cope with these complexities. Change is inevitable in everything and in order to cope, learners must learn to become adaptive and dynamic, must be able to evaluate cause and effect and know that the similar behaviors do not necessary obtain the same results (Hase & Tay, 2004). Hase & Kenyon (2003) note, “Self-determined learning assumes that people have the potential to learn continuously and in real time …they can be led to ideas rather than force fed the wisdom of others, and thereby enhance their creativity…People learn when they are ready” (p.4). Researchers have also noted the importance of heutagogy in the online and distance learning environment (Albon, 2006; Ivan, 2006; Keogh, 2006; Hase & Kenyon, 2007). Heutagogy is lifelong learning and assessment should be a learning experience.

The Internet has readily allowed students to be led to ideas on their own in real time. However, faculty are needed to facilitate this process. With the technologies available today and the ones that will likely be available in the future, heutagogy is a much more adaptive learning model. Hase and Kenyon (2001) note, “change is so rapid that traditional methods of training and education are totally inadequate…learning is increasingly aligned with what we do; modern organizational structure require flexible learning practices (p. 2) Teachers are no longer the holders and the deliverers of information. Information is readily available for whoever chooses to access it. What teachers can do is help students learn how discern the quality of the information available which is the crux of information and technology literacy. Blascke (2012) took the principles of heutagogy and compared it against the technologies available today. With
distance education increasing every day, she predicts heutagogy will become “the theory” for distance learning where the learner and the teacher are geographically separate. Students have to learn to obtain and use information on their own in this environment. Gerstein (2013), who coined the term Education 3.0, proposed a heutagogical approach is warranted with the insurgence in the popularity of Massively Open Online Courses (MOOCs) which have provide an alternative to traditional education as a form of gaining knowledge. Yet in the realm of creativity, new ideas are based on the old ideas of others. MOOCs leverage the sharing of ideas on a global scale.

Blaschke (2013) notes, “Heutagogy provides a theoretical framework for considering systems in a holistic way and the latest technologies service as agents for extending and supporting the framework” (Loc 1052). With technology students decide when where and how they can learn because information is readily available for most. Learners can connect with other learners and experts in the field of study.

Luckin et al. (2010) coined the term the Pedagogy-Andragogy-Heutagogy (PAH) continuum. In Table 1 the major characteristics of the PAH continuum are addressed as well as the corresponding characteristics of transformative learning. This table is compiled from multiple sources including Mezirow (1978-2006), Luckin et al., (2010), Blaschke, (2012) and Gernstein, (2013).

**Table 1. Comparisons of pedagogy, andragogy, heutagogy and transformative learning**

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Pedagogy</th>
<th>Andragogy</th>
<th>Heutagogy</th>
<th>Transformative Learning</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Delivery</strong></td>
<td>Teacher-directed</td>
<td>Student-directed</td>
<td>Self-determined learning</td>
<td>Self-determined and reflective</td>
</tr>
<tr>
<td><strong>Central theme</strong></td>
<td>Subject-centered</td>
<td>Skill-centered</td>
<td>Proactive learning</td>
<td>Critical reflection and thinking</td>
</tr>
<tr>
<td><strong>Creativity</strong></td>
<td>Very little</td>
<td>Some</td>
<td>Increased</td>
<td>Increased</td>
</tr>
<tr>
<td><strong>Motivation/Volition</strong></td>
<td>External (positive and negative reinforcement)</td>
<td>Internal</td>
<td>Self-efficacy</td>
<td>Internal and Reflective</td>
</tr>
<tr>
<td><strong>Faculty Role</strong></td>
<td>Deliverer of information</td>
<td>Facilitator</td>
<td>Developer of metality skills</td>
<td>Developer of self-awareness of strengths and weaknesses in regards to learning</td>
</tr>
<tr>
<td><strong>Reason for Learning</strong></td>
<td>Grades or to get to the next level</td>
<td>Professional advancement</td>
<td>Learning for its own sake</td>
<td>To solidify or change one’s perspective</td>
</tr>
<tr>
<td><strong>Context</strong></td>
<td>Resource-based</td>
<td>Experiential</td>
<td>Learner-generated</td>
<td>Experiential, learner-generated and reflective</td>
</tr>
<tr>
<td><strong>Autonomy</strong></td>
<td>None—dependent on teacher</td>
<td>Independent</td>
<td>Interdependent</td>
<td>Interdependent</td>
</tr>
<tr>
<td><strong>Grade Level</strong></td>
<td>K-12; lower level</td>
<td>Higher-level undergraduate classes</td>
<td>Graduate education (masters and doctoral level)</td>
<td>May happen at any point</td>
</tr>
<tr>
<td><strong>Taxonomic Level</strong></td>
<td>Understanding</td>
<td>Applying</td>
<td>Context-shaping</td>
<td>Context-shaping</td>
</tr>
<tr>
<td><strong>Meaning</strong></td>
<td>External</td>
<td>Filtered through personal experiences</td>
<td>Contextualized</td>
<td>Critical reflection on meaning schemes</td>
</tr>
<tr>
<td><strong>Learning</strong></td>
<td>Passive</td>
<td>Getting students to learn</td>
<td>Getting students to understand process of learning</td>
<td>Students reflect on their own learning</td>
</tr>
</tbody>
</table>
The combining of pedagogical models can also be an effective way to reach higher-level learning. Students have to start somewhere…initially, pedagogical theories may work best in order for the students to obtain the basic knowledge required for a specific field of study. However, the pedagogical model should not be retained indefinitely or the students never truly learn how to be self-reliant in the learning process. By the time a student is a junior or senior in college, these pedagogical models should be replaced by methods that lead to higher-level learning.

The reflective process of transformative learning can also be combined with the capability theories of heutagogy to enhance critical thought and creativity. To reach self-determined learning, a student must reflect on his/her own knowledge, including weaknesses and strengths. By reflecting, particularly on weaknesses, students can work to overcome these weaknesses or accommodate them.

Both of these models are adaptive. Yet both are also based on reaching specific competencies and learning outcomes. The measurement of these outcomes is traditionally done through the use of Bloom’s taxonomy.

**REACHING CREATING IN BLOOM’S TAXONOMY**

Benjamin Bloom created Bloom’s taxonomy in 1956 as a method of determining the level of learning a student was expected to attain about a particular concept. Bloom’s taxonomy is used to create learning objectives for both traditional and competency-based education. In Bloom’s taxonomy, “synthesis” is the second highest level of learning. In the updated taxonomy done in 2001 by Anderson et al. (a colleague of Bloom’s), the highest taxonomy level is “create.”

To be able to assess if a student has reached a particular competency level in Bloom’s taxonomy, the student must be assessed at the same level as the objective he/she must fulfill. If the taxonomy level of the objective or competency that is to be obtained is specified at a high level such as create, then in order to master this competency, the student does have to create something: this can include things such as a research project with data analysis, creation of a widget in a laboratory or a business plan in a course.

The problem therein lies in the fact faculty often write objectives at the higher levels of Bloom’s taxonomy, but do not create assessments which in fact measure this level of knowledge. Instructors use objective-type testing, such as multiple-choice tests, which can truly only measure the lower taxonomy levels such as knowledge and comprehension.

Designing assessments that truly measure whether a student has reached these high taxonomy levels of learning is much more difficult. You cannot pull a test pool out of a textbook and administer it and auto-grade it. In addition to taking a lot more effort on student’s level to actually reach these higher levels of knowledge, it takes a lot more work on the faculty member’s part to design an assessment that spurs both critical and creative thought and results in something that is inherently new (at least to the student). It also takes an immense amount of work to grade it. Many faculty do not receive format training in pedagogy and curriculum design; therefore, they just carry forward the teaching methods they were taught when they were in school decades before and the status quo continues to exist.

What does it mean to create in the context of Bloom’s taxonomy? Krathwohl (2002), one of the authors that updated Bloom’s taxonomy in 2001, defines the “create” taxonomy as, “putting together elements to form a novel, coherent whole or make an original product” (p. 215). Verbs used in the “create” taxonomy include words such as designing, constructing, planning, producing, inventing, devising, making and
many others. Andrew Churches (2009) added some digital verbs which include programming, filming, producing, publishing, animating and compiling. Technology opens up additional ways for students to reach the “create” taxonomy.

Shelly Wright (2012) notes teachers spend too much time at the lower taxonomic levels and never take students to the summit where create exists; she notes Bloom’s taxonomy should be flipped and students should start with creating and spend a great deal more of time at these higher taxonomies in order to gain additional critical thinking skills.

There are no hard and fast rules for designing an assessment that can demonstrate critical thinking in the “create” taxonomy. This can be very dependent on the subject that is being taught. However, there are some key factors in assignments that measure these two constructs (creativity and critical thinking). They:

- Are problem-based;
- Are as “real to life” as possible as to what students would be required to do on the job after their graduation within the artificial academic environment;
- Require discernment of various types and sources of information;
- Require the analysis of multiple governing variables;
- They have no true correct answer (there are exceptions such as the creation of something to specification); instead, there are multiple possible answers of which some are evidently better than others upon evaluation or;
- Assignments where students have choice in the journey, if not always in the correct result;
- Are meaningful;
- Are perceived as valuable by the students.

Henriksen, DeSchryver, Mishra and the Deep-Play Research Group (2015) point out there are two types of synthesis in education: synthesis for meaning and creative synthesis. Synthesis for meaning is commonly used in distance education where students are tasked to write a paper that synthesizes a number of facts to create meaning. However, they note creative synthesis integrates “senses, knowledge and experience in a multi-faceted manner” (p. 8). In addition, synthesis for meaning must occur before creative synthesis can exist.

Besides the topic that is being taught, the level of education itself will also govern the expected level of creation. For example, undergraduate students should not be expected to perform to as high of a level as graduate students. Masters-level students should not be expected to perform at as high of a level as doctoral students. Today, more than ever before, educators have more tools to create meaningful educational processes. Although a great educational experience can definitely be created without it, technology can greatly facilitate the creation of effective learning to enhance critical thought. Digital tools are readily available to get students attain this creative synthesis since it is now very easy to incorporate digital collages, mind maps, and video creation into course work.

Creativity is not in conflict with pedagogical thought. Instead, it can merge quite nicely with traditional objective-based learning and even emerging competency-based assessment. Particularly in competency-based assessment, creativity in ideas and thought is key to move a student from knowledge to true competency which includes usage and application of information in new and different ways. Technology can certainly facilitate this process.
LEVERAGING TECHNOLOGY AND CURRICULUM DESIGN

Can technology be used to enhance critical thinking and creativity? The answer is both yes and no. If the promotion of creativity and critical thinking is not considered in the curriculum design, and assessments are not designed to test these higher level constructs, then technology is not going to be a miraculous solution to this problem. In order to enhance critical thinking, the curriculum must be designed to measure critical thinking and promote it. This can be done with pen and paper - no technology is required.

In addition, in order to instill critical thinking and creativity in students, faculty members must also be willing to do what is required to make this happen. They must be willing to reflect and consider the ways they deliver content to their students. If the delivery is passive, then it is unlikely critical thinking and particularly creativity will occur except in small pockets of exceptional students. Using the newest technology out there to deliver passive content is not going to make an impact. If delivery is active and student-centered, then it is more likely either with or without technology that critical thinking and creativity will occur. However, if the faculty member is prescriptive and encourages convergent thinking and punishes divergent thinking (through poor grades, ridicule, etc.), then students will not likely explore the possibility of moving towards creative or critical measures no matter how many technological bells and whistles they have available to them. Rather, they will do what is required to get the grade they have to have so they can move on. However, they may never have truly learned anything; they just filled the squares. It can be very difficult for faculty who have been ingrained that there is a right and wrong way to do something to open themselves up to possibilities. There are definitely some cases where there are right and wrong solutions, but this is not the case with most things. The instilling of critical thinking and creativity is in the journey - not the destination.

If the curriculum design and pedagogies are open to promoting critical thinking and creativity, technology can certainly make a good learning experience better if it is used correctly. Technology is only a tool in faculty member’s tool belt, it is not the means to an end. If the faculty member is not comfortable using the technology or does not believe it in, then there is a significant possibility it will be a detractor rather than an enhancer to the educational experience. King (2002) looked at the steps faculty go through in relation to education technology. The initial stage is fear, the second stage is exploring, the third stage is connecting and the fourth is forming new perspectives. In an ideal world, faculty would not use the technology to enhance the learning experience until they reached the fourth stage or at least the latter part of stage three. However, because technology changes so rapidly, this ideal world is not possible. One potential solution if for faculty to pick one particular technology to use rather than experimenting with multiple types in their classroom if they do not have the proper skill set. If faculty are fearful or in the exploratory stages regarding technology, the students will definitely know it. Technology in the hands of inexperienced users can negatively impact their teaching practice.

Initially, technologies such as learning management systems, were leveraged as just a different way to provide the same education that was taught in the face-to-face classroom. When this was found to be ineffective, distance learning curriculum design was born to ensure a quality learning experience for distance students that included effective feedback and engagement. However, at this stage, the assessments given were often just like the ones given in the traditional teacher-focused classroom. Now once again, distance learning is reinventing itself (New Media Consortium (NLC), 2014). This reinvention has increased the potential for creative thought, critical thinking and creative assessment.

Today’s learners are “prolific creators of content” (NMC, 2014, p. 8). Although much of this is done in a social context, these methods can also be leveraged in the classroom to promote creative thought.
Although students may not be used to or even comfortable with creating content in a learning rather than an entertainment or social environment, it can be an effective way to leverage true learning. It can also be used to create a personal learning environment. Students are no longer consumers of education…they are creators (NLC, 2014). However, as Putnam (2007) postulated, even at this time, learners are using technology for personalized learning experiences much more widely outside the formal educational process. This is because faculty have not progressed as fast as students in learning and incorporating technology. To further personalize the learning experience in higher education, within the next five years adaptive learning is predicted to be in wider use in the formal education process. Adaptive learning technologies are a type of artificial intelligence that create dashboards based on algorithms which demonstrate how students interact with material and adjusts as needed for the learner (NMC, 2015). Future predictions include the Internet of Things (IoT) which connects the physical and information world through the web. This is part of what is now called the Internet of Everything (IoE) which is comprised of man-to-machine, machine-to-machine and person-to-person interactions where everything is globally connected. At this point, the potential of the IoE in higher education has not been realized in reference to its potential to increase creativity and relevance of education (NMC, 2015).

Currently there are several technology tools that can be leveraged to promote and assess creativity and critical thinking. Some examples from the 2015 Horizon report by the New Media Consortium are listed below in Table 2.

As of October 2014, 64% of Americans owned a smart phone, 42% had a tablet computer and 32% owned an e-reader (Pew Research Center, 2014). These percentages are likely to grow every year. These devices have the ability to facilitate self-determined learning. The sheer volume of technological choices can make this even more difficult for faculty. However, many students are well versed in using smart phones and tablets for social media and entertainment, but many are not well versed in using technologies for productivity tools or searching for scholarly information. This is another barrier that must be overcome. Technology cannot stand on its own. The success of the technologies in promoting critical and creative thought lies primarily in the curriculum itself. This includes scaffolding of the content to promote higher-level learning and problem-based assessment methods that are as real to life as possible as students enter higher education. No matter what the delivery system, the content and assessment are the critical components. Therefore, technology and creativity are not necessarily in conflict with today’s emerging pedagogies.

However, there are significant challenges with designing programs and courses that provide a personalized learning experience and promote creative thought. One is the current educational accreditation systems which are still embedded in traditional, faculty-focused teaching models and organizational structures. It is still difficult to leverage technology within the limits of current accreditation standards.

**Table 2. Sample technologies that can be leveraged to promote creativity and critical thinking**

<table>
<thead>
<tr>
<th>Technology</th>
<th>Potential Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>3D Printing</td>
<td>Creation of actual designs and project models; demonstration of sound or faulty design</td>
</tr>
<tr>
<td>Electronic Publishing</td>
<td>Measure of verbal creativity; demonstration of original thoughts</td>
</tr>
<tr>
<td>Games/Gamification</td>
<td>Allows the identification of globalizing variables; create alternate creative solutions</td>
</tr>
<tr>
<td>Augmented Reality</td>
<td>Allows the identification of globalizing variables; create alternate creative solutions</td>
</tr>
<tr>
<td>Crowdfunding</td>
<td>Promote critical thinking and creativity in the process of getting others to buy into an idea</td>
</tr>
</tbody>
</table>
At this point in time, universities are beginning to explore alternate avenues, such as competency-based education, which is now significantly enhanced by technology. However, they are facing barriers to this innovation in the traditional university structure which does not facilitate innovation and creativity in institutional processes. According to the NMC (2015), “higher education stakeholders are facing a reality that is difficult to digest; the paradigm that has worker for over a century is gradually becoming obsolete and universities must renovate...if they want to stay relevant” (p. 32).

Another problem is students and faculty still do not have all of the required information and metaliteracy skills required to leverage technology to its capacity. Students are still struggling with information literacy skills. According to the American Library Association (1989), information literacy is “a set of abilities requiring individuals to recognize when information is needed and have the ability to locate, evaluate, and use effectively the needed information” (p. 1). Information literacy includes information technology skills and the ability to seek out quality information. Information literacy skills allow students to move along the continuum from pedagogy to andragogy or heutagogy. However, information literacy is no longer enough with the advent of advanced technologies, particularly collaborative ones. Standard definitions of information literacy are insufficient for the revolutionary social technologies currently prevalent online (Mackey & Jacobson, 2011). Mackey & Jacobsen (2011) define metaliteracy as a “comprehensive framework that promotes critical thinking and collaboration in a digital age” (p. 62). In essence, it is the careful assessment of all aspects of information gathering. It is a unified construct that supports the acquisition, production, and sharing of knowledge in collaborative online communities. Metaliteracy challenges traditional skills-based approaches to information literacy by recognizing related literacy types and incorporating emerging technologies. Metaliteracy includes visual literacy, transliteracy, news literacy and digital literacy (Metaliteracy, 2015). To facilitate metaliteracy skill development in students, curriculum must contain multiple types of media.

PUTTING IT ALL TOGETHER: SOLUTIONS AND RECOMMENDATIONS

The call for critical thinking and creativity in higher education and in the workplace is likely to increase as the world becomes ever more complex. There are not definitive answers on how to ensure students reach the levels of thinking discussed throughout this chapter. It is likely these levels of thought are not possible for all students. However, educational theories, such as transformative learning and heutagogy, can be used as the basis of creating university curriculum that is robust and provides a meaningful learning experience. More time needs to be taken in teaching students how to learn and become self-directed and self-determined learners, rather than measuring how well they can regurgitate facts. But students do need to still memorize facts and figures. For example, you cannot become a microbiologist if you do not know the different species of bacteria and their characteristics. However, to become a really effective microbiologist, you must also be able to identify a bacteria that does not conform to what is expected. This requires critical thinking skills.

Students also need to be taught how to be responsible for their own learning in order to become self-determined learners. This includes metaliteracy, reflection on their own abilities and true assessment of their strengths and weaknesses, as well as accepting and acting upon faculty feedback. Part of the educational process is also to assist students in learning motivation, and most importantly, volition, if these are lacking. In addition, students need to become divergent and non-linear thinkers who question and evaluate the knowledge they gain rather than blatantly accepting the ideas of others. Students must also
learn to question others in a positive manner to seek knowledge. Since creativity is literally ideas built upon other ideas, this questioning is an important concept needed for creative and constructive thought.

Can technology be leveraged to promote heutagogy or self-directed learning in students? Absolutely it can! Can it be used to promote critical thinking and creativity? Certainly it can! Augmented reality, virtual reality, gamification and other technologies can enhance creative thoughts, but only if it used effectively as part of a robust curriculum. The robust curriculum should include problem-based assessment that encourages critical and creative thought. Perhaps the most critical piece is that faculty also need to accept answers from students that may deviate from the norm and encourage creative thought; divergent thinking should be rewarded if it is not flawed.

Technology impacts pedagogical choices in the 21st century. Particularly in distance education, there is no way for faculty to avoid using learning management systems and Internet technologies. Technology is perfectly suited and poised to assist students along their journey in the PAH continuum to heutagogy. Heutagogy is self-determined learning…literally, technology is what makes this available at our fingertips.

The movement for faculty from teacher to facilitator is a difficult one for many faculty members, let alone a transition from teacher to coach and advocate and teacher of student metaliteracy. It is a loss of control and faculty who are embedded in teacher-centered models need to transform. This may not be easy. However, it is only if the faculty and student transform that self-determined learning can actually occur. Technology is not required for this process; however, technology can be useful to faculty who have difficulties in making this transition because it provides an alternate modality that can be used to encourage creativity, critical thinking and move students along the continuum to self-directed learners.

CONCLUSION

Technology will continue to play an important part in learning in the future and it can be leveraged to promote higher-level learning among students in higher education. However, technology is only as good as its facilitator. Robust content and proper assessment are needed in order for students to become creative and critical thinkers. Exposing students to as much as possible in the classroom that is real-to-life can assist them when they transition into the workplace. In addition, building skills such as volition and motivation in the educational process also prepares them for what they will face in life since life does not follow a linear path.

REFERENCES


Reaching “Creating” in Bloom’s Taxonomy


Reaching “Creating” in Bloom’s Taxonomy


ADDITIONAL READING


Reaching “Creating” in Bloom’s Taxonomy


KEY TERMS AND DEFINITIONS

- **Bloom’s Taxonomy**: A system devised by Benjamin Bloom in 1957 to define levels of human cognition and learning.
- **Constructivism**: Learning epistemology where knowledge is created through interaction between their experiences and ideas (or content).
- **Creativity**: Looking at things differently and questioning pre-conceived notions; development of original ideas or thought.
- **Critical Thinking**: Evaluating all aspects of a decision to make an educated decision.
- **Heutagogy**: Self-determined learning.
- **Self-Determined Learning**: Self-regulated and self-directed learning; internal motivation to learn.
- **Self-Directed Learning**: Taking action and responsibility for one’s own learning.
Chapter 20

Applying Blooms Digital Taxonomy to Address Creativity and Second Order Digital Divide in Internet Skills

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ABSTRACT

Internet technologies play a significant role to enhance creativity of the students in learning environments. Internet literacy is vital to effectively use the Internet tools to enhance creative learning environments. In the developing countries Internet literacy is still an unfulfilled dream for students coming from underprivileged backgrounds thus bringing a digital divide in skills. The chapter draws upon an empirical study done in India on how an intervention comprised of Internet training designed on Bloom’s Digital Taxonomy and action research workshops based on the learning domains of the digital taxonomy was an effective approach for empowering women students through learning to use the Internet. The chapter puts forward the argument that an intervention for learning to use the Internet can be effective where focus is on the reflective and conceptual skills in using the Internet than focusing too much on the content that is dynamic.

ICT AS A TOOL FOR DEVELOPING CREATIVITY

Information and Communication Technologies (ICTs) are considered to have the potential to revolutionize the educational system and to make the students equipped for the new information age with improved learning attitudes (Assar, Amrani, & Watson, 2010; UNESCO, 2011). In todays time, there is a growing engagement with a new learning culture mediated by ICT and this orientation rejects the passivity of learning, and seeks opportunities for creativity, social connections, and personal growth (Purushothaman & Zhou, 2014). ICT can be seen as a set of tools which facilitate the creative process and the characteristics of ICT can make a distinctive contribution to those processes, providing new tools, media

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and environments for learning to be creative and learning through being creative (Loveless, 2002). In learning contexts, creativity offers opportunities to shape new knowledge and can be viewed as a key driver for individual learners to engage in activities with their peers (Purushothaman & Zhou, 2014).

Out of the ICTs, Internet is considered as the most powerful tool that brings immense opportunities to improve the learning scenarios of students across the globe. Internet enable the students to access information sources from various parts of the world, giving them the opportunity to choose from an updated repository of materials within a short span of time (Kabilan & Rajab, 2010; Nwagwu, Adekanbni, & Bello, 2009). The ease and speed with which knowledge is accessed and disseminated through the Internet from information sources around the world encourage the educational institutions to invest in Internet infrastructure and technologies for the benefit of staff and students (Nwagwu et al., 2009).

However, what is seen is that digital literacy is a primary barrier for access and usage of Internet (Radovanović, Hogan, & Lalić, 2015) and to take advantages of the enormous potential that Internet has to offer, requisite Internet skills is imperative (van Deursen, Courtois, & van Dijk, 2014). The chapter discusses the relevance of Internet skills needed in todays creative learning context and how some sections of the population are not getting advantage of this new age learning tool. It is imperative to look into, if there are learners who are left behind and not able to reap the advantages of Internet technologies that are transforming the learning scenarios across the globe. With Internet skills becoming indispensable for enhancing the creative learning opportunities for the students of this generation and in future, what are the best approaches for making students coming from underprivileged backgrounds to learn how to use the Internet needs to be addressed.

Learning to use the Internet is challenging for new users and who does not have ownership of computers and Internet. Novice users does not have the requisite navigational and operational skills and they can often get lost in the enormous pool of information that a web search can give. The author discusses how blooms digital taxonomy was used as a methodology for making the students coming from underprivileged background to learn the reflective and conceptual skills in using the Internet, which is a life long skill.

INTERNET SKILLS: INEVITABLE FOR CREATIVITY IN LEARNING

Out of all the ICTs, Internet technologies plays a vital role in bringing creative ways of learning and engagement opportunities for learners of this generation. The rapid expansion of free electronic educational material on the Internet has given those fortunate enough to have access to it in a new way of acquiring information (Hatakka & Lagsten, 2012). Internet technologies have accentuated the need for creative thinking in all aspects of our lives, and have also provided tools that can help us improve and reinvent ourselves and has called for a growing engagement with a ‘making and doing’ culture for creativity (Zhou & Purushothaman, 2015).

It is seen that the Internet technologies can have transformative powers in the development of educational organizations and for students in developing regions; people from rural areas have the opportunity through applying online to universities and colleges, which ensures that the physical distance is not a hindrance to the admission process; and they also have the opportunity of enrolling in a formal degree program offered by educational institutions online (Hatakka & Lagsten, 2012). Moreover, people from developing regions can also make use of acquiring skills through the informal courses available through the Internet (Perez & Ben-David, 2012). However, as any other new technology, the Internet has been unequally distributed across societies and therefore does not offer the same opportunities to everyone
or every social group to the same extent (Pan, Yan, Jing, & Zheng, 2011; Walton, Yaaqoubi, & Kolko, 2012). Apart from the infrastructural and connectivity issues that bring barriers in the access and usage, there is also a reported divide in Internet skills to use the available access. It is reported that a large portion of the world’s population lack the requisite skills to take the full advantage of the opportunities and economic growth the Internet can provide (GITR, 2015).

SECOND ORDER DIGITAL DIVIDE IN INTERNET SKILLS

Apart from the first order factors that brings digital divide in terms of connectivity and infrastructure, there is also a second level of divide, which bring disparities in Internet usage. Second order divide in Internet access and usage can be due to human (lack of information retrieval or digital skills), socio-cultural, psychological, and behavioral dynamics. One of the major factors which contribute to digital divide and social inequality in Internet usage is insufficient skills to use the Internet (Gui & Argentin, 2011; Hargittai, 2006; van Deursen et al., 2014).

Internet search can give an inconceivable volume of information with many links and resources that are unstructured making it look chaotic (Edwards & Bruce, 2002; Hargittai, 2006; Lazonder, 2000). The diverse paths of navigation and usage options in the Internet can make the users too confused to obtain the requisite information (Iske Lazonder, Klein, Kutscher, & Otto, 2008). Information seeking is thus challenging through the Internet because it assumes a number of new operational and formal skills to begin with (A. J. A. M. van Deursen, Dijk, & Peters, 2012). Those who fail to find relevant information online are at a disadvantage; for the digitally literate, finding the relevant information out of the increasing amount of information relating to daily life is quick and easy (van Deursen & van Dijk, 2010a).

In the wake of information revolution and the digital age we all are living in, there is a need for answering the significant question on if the learning opportunities provided by Internet technologies are benefitting all students across the globe, or if some are left behind. Students having the sufficient skills to use the Internet will make more creative opportunities which the new technologies can provide, thereby moving far head in the digital world than who lack the skills to make use of the available access. Apart from addressing the issues on connectivity and infrastructure, there is also an equivalent need to address the issues beyond connectivity, which is the lack of adequate skills to use the available access, especially in developing countries.

This is very significant considering the reported inequalities in digital skills even in highly wired countries. Even in developed economies with a higher rate of Internet connectivity, students are not always successful in finding online contents and services that are easy to access and use (Correa, 2010; Livingstone & Helsper, 2010) and there is a reported inequality in Internet skills and problem-solving behaviour (Gui & Argentin, 2011; Hargittai, 2010; Hope Cheong, 2008) and inadequate knowledge and digital competence when it comes to high-level technological and cognitive skills (Calvani, Fini, Ranieri, & Picci, 2012). Despite the experiences, the Internet can be disruptive and sometimes a misleading resource and disadvantages of disruptive navigation can result in superficial knowledge and it is often seen that students’ ability to make structured research is based on the practical applicability in the professional practice where they are a member (Purushothaman & Dau, 2015).

Learning to use the Internet could be more challenging and a perplexing task for students coming from marginalized sections of the society in developing regions since majority does not have household ownership of computers and Internet connection. Imparting the Internet skills to equip the students to
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make best advantage of the Internet medium can thus be challenging for educators and developmental scholars. Giving training to equip the students with Internet skills can be challenging when students don’t have a connection back home to practice and use. Learning techniques and activities that can make learning more interesting and motivating for the students within available research and fieldwork time is imperative. When people have inadequate level of Internet skills, they either learn by trial and error, or rely on various kinds of informal support or acquire skills through formal support in the form of training (van Deursen et al., 2014). The chapter demonstrates that imparting Internet skills based on a training designed on Blooms digital taxonomy of learning domains followed by action research workshops based on the learning domain can make learning more motivational and effective than a technical oriented training.

EMPIRICAL CONTEXT

The empirical study discussed in this chapter is an ethnographic-action research project done at a University in Southern India to empower women users through learning to use the Internet. The research group comprised of twelve women students from first semester. The overall aim of the research project was to understand what barriers kept the women students from using the Internet and how they can be trained to develop their Internet skills so that they are not left apart in the information age. It was found that out of the twelve students in the study only two had computers with Internet access at home. Only three students out of the twelve students in the group had some knowledge on how to use the Internet. Only four of the students had an email account and three had a chat ID. Lack of knowledge and skills to use the available Internet access certainly represented a barrier for the students in the research. Access was not out of reach for the students as they had the scope for limited access. They were master’s students, and educational level was therefore not an issue that hindered access. They had the opportunity to use three different Internet cafés within 100 meters of their department. However, it was identified that even though they had the opportunity to access the Internet, most of the students did not have the requisite knowledge to make use of the access. The availability of an Internet connected computer is of no use if the necessary skills to access and retrieve information are missing.

In the research context, questionnaire data revealed that nine of the students did not know how to get connected to the Internet. In the research context, ‘getting connected’ is understood on the very basic level as some students did not even know how to use a web browser, which Dimaggio et al., (2004) call the “recipe knowledge about how to log on” (p. 32). Most of the students did not know the names of web browsers and even lacked the knowledge on how to click and get connected and often had trouble handling the keyboard and using the mouse for navigating.

Some of the students statements which reflected their lack of knowledge and skills to use the Internet are as follows: Anuradha: “I haven’t learnt anything about the Internet. I want to know everything. I don’t know anything” Anuradha had attended a basic computer course concerning Microsoft Office skills, but she did not know how to use the Internet.

Bindu expressed that “Just like everyone, I have learned [to use a] computer from eighth standard to tenth standard in school. Haven’t learned anything from outside. I want to learn everything about the Internet” What Bindu means by “not learning anything from outside” is that she has not attended private computer courses like some of the other students in the groups.
Soumya stated: “I know the basics about the Internet. Like Deepa, I face difficulties in searching for information for seminar topics. I know the information is there but I’m not able to download it. The other day we were looking for some information about scholarships. We could see there are a lot of scholarships. We’re not able to download what we wanted. I know some basics”. Soumya had a computer at home but she did not have an Internet connection; however, she did manage to use the Internet at the university Internet center and sometimes at public Internet cafés. She compared her difficulties in getting the correct information through the Internet to Deepa because Deepa used the Internet in a similar manner. Soumya’s reflection illustrates that even though she knows some basics, she faces difficulties in searching and retrieving information.

Lakshmi: “I don’t know anything about the Internet. I want to know all the basics about the Internet” (FW). Lakshmi was another student in the group who had inadequate Internet skills and actually knew nothing related to Internet usage. She reflected, like almost all the other students in the group, that she wanted to know all the basics about the Internet.

Thus, the students’ reflections revealed that even though they had computer studies as a subject from eighth grade to tenth grade in school, most of them did not know how to use the Internet because of the lack of practical knowledge in using computers in general and the Internet. Some of the students had even taken some private computer courses, which were about basic word processing and data processing skills. However, the courses had been of poor quality and did not provide the scope for using the Internet. They all stated that they wanted to know all the basics about the Internet, mainly searching and retrieval of material.

Thus, the learning activities were selected keeping in mind the ownership of a computer and Internet connection and the previous and existing level of Internet usage of the students. Selection of the respective Internet tools and applications were made keeping in mind that the participants were master’s students and how these tools and applications might contribute to the students’ academic activities and future endeavors in life. Consideration was also given to the restricted time of the research, in imparting the students training in Internet skills. The Internet training for the students was given in the nearby public Internet cafés of the university. The university did not allow the use of students’ class hours, so the training was given in the morning before the normal class hours started and in the evening after the classes. Internet activities for the action research workshops were also conducted at the nearby Internet cafés.

RESEARCH DESIGN

Blooms Digital taxonomy of learning domains was adopted to design the learning and assess the students learning in this research project. Bloom’s Digital Taxonomy, adapted by Churches (2007, 2008), focuses on the actions and learning behaviors in the new digital age. Dr. Benjamin S. Bloom developed Blooms Taxonomy in 1950’s where he categorized different cognitive domains. These cognitive domains include educational objectives associated with the attainment and development of knowledge and intellect (Karns, Burton, & Martin, 1983). The original taxonomy had six major categories of cognitive domains which were: Knowledge, Comprehension, Application, Analysis, Synthesis, and Evaluation (Karns et al., 1983; Krathwohl, 2002; Ying & Yang, 2008). These cognitive domains were arranged in a cumulative hierarchical structure, increasing in complexity from the simplest level to more complex levels (Krathwohl, 2002; Madaus, Woods, & Nuttall, 1973).
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In 2001, Bloom’s Taxonomy was revised by Anderson and Krathwohl(2001), who retained the original number of categories, but made important changes. Three categories were renamed; the verb aspect of the original “Knowledge” category was kept as the first of the six major categories, but was renamed “Remember”; “Comprehension” was renamed “Understand”; and “Synthesis” was renamed “Create”. “Application, Analysis, and Evaluation” were retained, but in their verb forms as “Apply, Analyze, and Evaluate,” and Krathwohl (2002) argues that highest two levels of the taxonomy should be reversed, with “create” at the highest level and “evaluate” at the second highest level. Bloom’s Digital Taxonomy was developed by giving emphasis on the actions and learning behaviors in the new digital age where the information literate can access, evaluate and use digital information efficiently (Churches, 2007, 2008). Churches felt a vacuum in the revised taxonomy by Anderson and Krathwohl (2001) as it failed to address the newer objectives, processes and actions represented by the emergence and integration of ICT’s. To overcome this vacuum in the revised Digital Taxonomy, Churches adds new digital verbs to the recognized and existing verbs. The Digital Taxonomy is not about the tools and technologies; instead, it focuses on how to use these tools and technologies to achieve levels of learning. This digital taxonomy can be applied for bridging the digital divide as the approach can make the learning more organized from the designer’s point of view and less cumbersome and chaotic from the learners’ point of view.

Churches (2007, 2008) states that it is not necessary that you require some of the stages for each task, action or process and the choice is up to the individuals. The learning domains were not used specifically to understand the learning process or achieving respective domain for the individual Internet tool or application introduced through the research. What was looked into was how the learning domain was achieved as regards learning to use the Internet from a holistic perspective. In the research, Bloom’s Digital Taxonomy was used to categorize and order the thinking skills in terms of how the students learned to use the Internet. When a person who has not used the Internet before is given training, the order of training should start from learning basic Internet skills and move to higher the skills. So the rationale behind selecting the activities under each domain as recommended by the digital taxonomy is based on the complexity of the Internet activities introduced. Therefore, the students will start to learn from the least complex activity and as they move up the process of learning, the more complex Internet activities will be introduced.

Each training session was based on Internet tools and applications selected based on respective learning domain from the list of possible activities suggested under blooms digital taxonomy. After the training session based on each domain an action research workshop was conducted. “A workshop is a short-term learning experience that encourages active, experiential learning and uses a variety of learning activities to meet the needs of diverse learners” (Brooks-Harris & Stock-Ward, 1999, p. 6) . Action research helped in building a project that facilitated the students to learn to use the Internet from each other in the group (Figure 1).

The students were trained to use the Internet, and action research workshops were used as a method to reflect on the learning. Conducting action research workshops after each training session, helped the students to recall the learning faster. If the workshops were designed to be conducted after all the training sessions were completed it would have been difficult for the students to recall what they had learned in the training sessions conducted several weeks before.

In the action research workshops, the students shared their learning experiences in the group, the problems they faced in getting the correct information and the difficulties in using the various tools and applications that they were introduced to through the research; in this way, they also learned from each other. Action research helped in bringing the desired change through using the Internet for the
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Figure 1. Internet training and action research workshops designed in the research

participants through the interventions. The research demanded high levels of user participation as it was about learning to use the Internet and involved learning by doing. The reflective approach and the cycle of plan, act, and reflect in the action research methodology helped to make the participants reflect on the process of Internet search and to learn from each other in the group through discussing the Internet learning activities. This participative and reflective aspect of action research made learning to use the Internet more effective than when they are given traditional face-to-face training that would have made the learning unexciting. In addition, by observing the change happening to the students through learning to use the Internet and through documentation, flexibility was provided to improve the project to bring better results.

This design facilitated more participation and involvement of the research participants than technically based training could have done, usually seen in the Information and Communication Technologies for Development (ICT4D) context, the umbrella under which the research comes under. Each domain is explained in brief under each training session as to what it means in the revised model of Bloom’s taxonomy (Krathwohl, 2002), and what it means in the digital taxonomy (Churches, 2008, 2009).

Internet Training: Phase 1 (Remembering)

The first session of Internet training was given to the students based on Bloom’s Digital Taxonomy of learning domain of “Remembering.” “Remembering” is to recall, recognize and retrieve specific information from long-term memory (Krathwohl, 2002, p. 215). Key verbs associated with “Remembering” are: recognizing, listing, describing, identifying, retrieving, naming, locating and finding (Churches, 2008, 2009). The digital verbs associated with “Remembering” are bullet pointing, highlighting, bookmarking, social networking, social bookmarking, favouriting / local bookmarking, and Google search (Churches, 2008, 2009). The potential activities selected for training based on the learning domain of “Remembering” was:

- Google Search.
- Google Books.
- Google Scholar.
- Creating Email IDs and Social Networking IDs.
- Delicious.

In this phase of training and workshops, students were expected to achieve a familiarity with the key element of the taxonomy in a digital medium, which is the retrieval of material. Learning outcomes
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for the students through the first phase of Internet training based on Blooms Digital Taxonomy were searching skills, bookmarking, and networking. The first activity introduced to the students was how to search and retrieve information from the Internet. Search engines and their uses are key elements for students’ searches (Churches, 2007, 2008). Students were introduced to the Google search engine and how to retrieve materials and information from simple search strategies. Google was used because, as argued by Churches (2009), it has become the default search tool even though there are other search engines available in the Internet.

They also acquired knowledge on how to search for scholarly articles through Google Scholar and how to find books online by using Google Books. Google Books and Google Scholar were introduced as learning tools even though they are not mentioned in the digital taxonomy. These two possible activities were introduced under this learning domain, as Google Books and Google Scholar are educational tools through which students can get access to innumerable books and scholarly articles that can add value for the academic activities. Learning to use Google Books and Google Scholar is concerned with searching and retrieving information, thus getting familiarized with key verbs associated with the learning domain of “remembering” such as recognizing, identifying, locating and finding. Since Google was familiar to all the students, most of the activities selected for learning for imparting Internet skills were Google tools so that they could identify and relate with the Internet activities selected.

Another activity, which the students learned, was bookmarking Websites. Bookmarking involved using favorites and bookmarks in Internet browsers and introducing the Web 2.0 tool Delicious. They became familiar with how to add URLs to the favorite folders in web browsers of computers and also to add URLs to the social bookmarking site Delicious. They learned to use Delicious in its simplest form – saving bookmarks an online format rather than locally on the machine (Churches, 2009).

Another possible activity at the lowest level of the taxonomy recommended by Bloom’s digital taxonomy is social networking. Through social networking people develop networks of friends and associates (Churches, 2009). The students were trained how to create an email IDs because only four of the students had an email ID and having an email ID is the basic requirement for communicating and networking in a digital world. Moreover, an email id is often the basic requirement to create online profile for most of the social networking sites.

Learning Outcome from Internet Training Phase 1

Even though the recall of knowledge is the lowest level of the taxonomic levels, it is crucial to the process of learning (Churches, 2009). In this phase of training and workshops, students were expected to achieve a familiarity with the key element of the taxonomy in a digital medium, which is the retrieval of material. Since it was the first phase of training, the focus was on the operational Internet skills, mastering the navigation skills and not getting disoriented in the search (van Deursen et al., 2012; van Deursen & van Dijk, 2009). How to navigate on the Internet and having a sense of location while going within the site and from one website to another and not becoming disoriented when browsing through, and opening search results.

They were also expected to be familiar with bookmarking and networking. Learning outcomes for the students through the first phase of Internet training based on Blooms digital taxonomy are as follows.

• Searching Skills: Students learned how to retrieve information from the Internet using the Google search engine. They gained skills on how to search the Internet by using basic search techniques.
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They also acquired knowledge on how to search for scholarly articles through Google Scholar and how to find books online by using Google Books.

- **Bookmarking**: Students learned how to bookmark the websites for later use. They became familiar with how to add URLs to the favorite folders in web browsers of computers and also to add URLs to the social bookmarking site Delicious. Students gained skills to use social bookmarking sites such as Delicious to store the URLs that can be accessed from any computer. This will help them to retrieve the websites for later use and will prove useful, as most of them did not own a PC or laptop.

- **Networking**: Students created email IDs and social networking IDs. Through these networking skills, they gained the opportunity for self-expression and to create an online identity. This will help the students to develop networked relations and improve their communication level across the Web.

### Internet Training: Phase 2 (Understanding and Applying)

The second phase of Internet training was designed based on the learning domains of “Understanding” and “Applying.” “Understanding” builds relationships and links knowledge (Churches, 2009). The cognitive process is represented through key verbs that include interpreting, summarizing, inferring, classifying, comparing, explaining, and exemplifying. Digital verbs associated with “Understanding” are advanced and Boolean searching, categorizing, tagging, commenting, annotating, and subscribing (Churches, 2008, 2009). “Applying” implies carrying out or using a procedure in a given situation, and the verbs, which describe the cognitive process, are implementing, carrying out, using, executing, showing and exhibiting (Krathwohl, 2002). Digital verbs associated with “Applying” are running, operating, uploading, sharing, hacking and editing (Churches, 2008, 2009).

The learning activities for gaining Internet skills from the learning domains of “Understanding” and “Applying” were:

- **Boolean Search**.
- **Word Processing**.
- **Google Doc’s**.
- **PowerPoint**.

Boolean search is more complex than a simple search. In order to do Boolean searches “[s]tudents require a greater depth of understanding to be able to create, modify and refine searches to suit their search needs” (Churches, 2009, p. 17). Boolean searching was introduced in this training phase so that students gain Internet skills to use Boolean operators and search strategies and could make more refined searches that can bring them better search results. The students learned how to search, select, and evaluate information in digital media thus gaining informational Internet skills (van Deursen et al., 2012; van Deursen & van Dijk, 2009).

Word processing was selected as a learning activity for the students because it facilitates the digital activities of collecting, summarizing and explanation (Churches, 2009). When a student searches and retrieves information, the data has to be collected and presented in some form. When students learn how to create a Word document, they can collect and present the online data and can take copies and printouts for future use. This was important to them as ten out of the twelve students in the group did not have
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Internet connection at home and the only scope of access was University and public Internet cafes. So learning the skill of how to save and take printouts was crucial to these students.

To learn how to collaborate online and develop a shared document, Google Docs was selected as an activity introducing them to the concepts of editing, sharing, and collaborating online. This activity was somewhat difficult for the students and it was observed that most of them were confused and in doubt on how to share and edit. PowerPoint was also selected as a learning activity in order for them to learn how to do a digital presentation to an audience. Students were expected to do an individual seminar presentation based on topics from their curriculum. Usually they would do this only with the help of handwritten notes. PowerPoint was introduced so that they could use it as a tool for their presentations in seminars.

Learning Outcome from Internet Training Phase 2

- **Advanced or Boolean Searching:** Students learned how to do a Boolean search using Boolean operators “and, “or”, not” using Google. The students gained skills on how to modify the keywords and refine the search for getting better and accurate search results.
- **Word Processing:** Students acquired the skill to create, edit, save, and take printouts of the Word files. They gained an understanding of some of the features of Word processing such as “cut and paste,” copying, deleting, and inserting text, and inserting tables, pictures and images. Even though this was not an Internet activity, it was important because presenting information from the Internet is an important skill.
- **Collaborating Online:** Students learned how to collaborate online through working on Google Docs. This helped them to acquire knowledge on how to create and edit a document through collaborative working in an online environment.
- **Presenting the Data in a Digital Format:** Through learning to create a PowerPoint presentation, they learned how to present data in a digital format. They learned how to insert text, images and how to save the PowerPoint file and how to present it as a slide show.

Internet Training: Phase 3 (Analyzing and Evaluating)

The third Internet training session was based on the learning domains of “Analyzing and Evaluating.” “Analyzing” means breaking material into its constituent parts and detecting how the parts relate to one another and to an overall structure or purpose. The cognitive process associated with this key term are differentiating, organizing and attributing (Krathwohl, 2002). The Digital verbs for “Analyzing” include mashing, linking, reverse engineering, cracking and mind mapping.

“Evaluating” implies making judgments based on criteria and standards and verbs that explain the cognitive process are checking and critiquing (Krathwohl, 2002). The digital verbs associated with “Evaluating” are blogs and video blogs, commenting, reflecting, posting, moderating, collaborating networking, testing and validating. The learning activities based on the learning domains of “Analyzing and Evaluating.”

- MindMeister
- Google Forms
- Google Calendar
- Google Maps
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To introduce the concept of mind mapping, the students were taught to use the online tool MindMeister. Through learning to use this tool, they learned how to construct meaning and relationships with digital data. Google Maps was selected so that the students could investigate an online environment and learn to use a geographical information system. They became familiar with how to find directions, navigate as well as using zoom in, and zoom out. Google Forms was introduced with the motivation of giving the students an experience of how to do an online examination. Usually Google Forms is a series of questions that are set by a user and published on the Web for people to answer (Churches, 2009). Google forms were used as an online test with multiple-choice questions. They only answered the questions and did not process the answers using the spreadsheets. To learn how to organize data online, students were familiarized with Google Calendar. The intention was to present a way of using the Internet for managing their daily activities and for collaborating with others.

Learning Outcome from Internet Training Phase 3

- **Constructing Meaning and Relationships**: Students developed an understanding of how to construct meaning and build relationships through the digital data. They learned to use a mind-mapping tool and learned how to build concept maps to build ideas and relationships around them.
- **Differentiating and Attributing**: Students experienced doing an online test using Google Forms where they were given multiple-choice questions requiring them to search for answers on the Internet and pick the correct one.
- **Investigating**: Through Google Maps students learned how to navigate and find places in an online environment.
- **Organizing**: Through learning to use Google Calendar, they gained knowledge on how to organize data online.

Internet Training: Phase 4 (Creating)

The fourth phase of the Internet training was based on the learning domain of “Creating.” Creating implies putting elements together to form a coherent or functional whole, and the key verbs which describe the cognitive process are generating, planning and producing (Krathwohl, 2002). The digital verbs connected to “Creating” are programming, filming, animating, video casting, podcasting, mixing and remixing, publishing, directing, producing, building, and compiling mash-ups. The emphasis of the research project was to introduce the students to concepts of creating digital document. Churches (2009) state that a digital document is not limited to a word processed product, rather it could be a blog, a wiki entry, a web page, slideshow presentation, DTP product etc. Content creation Internet skills is the skill to create content to be published on the Internet in the form of text, music and video, photo or image, multimedia and remixed content (Van Deursen, Helsper, & Eynon, 2014).

The activities selected for the learning domain of “Creating” based on Bloom’s Digital Taxonomy.

- Twitter
- Blogging

The digital activity that was selected for learning in the final stage was publishing. In this training session, all the students created a blog page and created Twitter ID, which is a micro-blogging site.
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They were quite fascinated by the fact that they could be in touch and could send direct messages to their favorite personalities from arts and literature. The other activities in the learning domain of “creating,” for example programming, filming and animating, would have been more complicated for the students as they have not reached the skill level where they could do these activities within the limited time frame of the research. Therefore, publishing digital content, as the learning activity was limited to twitter and blogging.

Learning Outcome from Internet Training Phase 4

- **Publishing**: The students gained an insight on how to create data and post it online. They learned how to use a blog and how to get it published. They also gained knowledge on how to use the micro blogging site Twitter. Thus, students gained the confidence to create text and publish online.

RESULTS AND DISCUSSIONS

Mixed tools were used in evaluating the knowledge and skills as an empowered outcome in the research context. A standardized achievement test can help in assessing the success of an educational program, while an interview or observation can help in understanding why the program was successful or unsuccessful (Greene, Caracelli, & Graham, 1989). Similarly, as knowledge and skills were indicators of empowerment outcomes through the research, the numerical data on their knowledge levels of the tools obtained through the online test, aptitude test and knowledge level questionnaire before and after the workshops helped in evaluating the knowledge and skills as an empowered outcome. The verbal statements, which produced textual data, helped in answering the “how” question of how they gained knowledge and skills in using the Internet. In this research context, focus on the skills gained to use the Internet was not based on parameters of time spent on the Internet or frequency of applications and tools introduced to them through the research. What was given thought and consideration was that out of the twelve students, only three students in the research were familiar with using the Internet. Emphasis was on the reflective and conceptual capabilities on how to use information and content available on the Internet. The students’ improved Internet skills were clearly seen in the refection sessions in action research workshops. Improved knowledge levels were also reflected in the questionnaire that was given to measure the knowledge on the tools introduced before and after the workshops. A questionnaire on empowered outcomes also showed improved knowledge levels after the intervention and also one and a half year after the intervention. What was also reflected was their improved Internet self-efficacy beliefs in using the Internet, and reduced technophobia through the Internet skills they gained. Student’s reflections in action research workshops, which showed improved knowledge in using the Internet, are discussed as follows.

In the first action research workshop, Reshma reflected on the Internet usage experience on searching information about the world’s most powerful women according to Forbes magazine as follows, *We did a Google search, and we typed the search words as ‘Forbes’ and then ‘world’s most powerful woman’… to type short words, that’s the best thing to do…we got the correct information, there was another option where we could have gone to the magazine website and searched for the information, which would have been difficult.*
Reshma’s reflections show improved knowledge and skills through the three important elements of web searches; orientation, sense of location and identifying the key organization, as stated in the literature (Edwards & Bruce, 2002; Kwan, 2001; van Deursen & van Dijk, 2010b). Their search process reveals that while they were doing the Internet search, they were not disoriented, as they did not get lost in the Internet environment. Also, the group was not confused with identifying the search results, as they could easily find the correct information, and they had a sense of location while navigating through the search results as well as within the website of Forbes. They were also successful in identifying the key organization related to the query, which was the Forbes Magazine homepage.

In the second action research workshop, Deepa reflected on how her group found information about women’s educational status in India as, Concerning women’s educational status in India… we went to the government’s census records… we accessed that site and got the information from there…we entered after looking into what the site was…so we were fast…when we started to read, we got the information fast and then we shared it in Google Docs.

The elements of a web search which is reflected here through Deepa’s reflection are identifying key organization, acting on the planned search and not getting disoriented. These elements have been identified in the literature for an efficient web search (Edwards & Bruce, 2002; van Deursen & van Dijk, 2010b). Instead of doing a Google search, they identified the government census as a source of information. They had this in mind while doing the Google search and from the search results they directly went to the government census site. This shows that they were breaking down the search topic by asking what the key organization related to the topic is, similarly to Reshma’s group. When they went to the government census website, they did not get disoriented while looking for information within the website because they found the information fast. They were acting on a planned search by checking whether it was the correct website on government census before entering the website.

In the reflection session in the second AR workshop Soumya reflected to the whole group on how during the Internet activities in the second action research workshop, their group used commas and short words to get better Internet search results, which they had learned during the Internet training: Instead of going for a wide keyword, give specific words. We did not type the word “world” so we could not get the information in the first search. Likewise, put commas and make short words.

Soumya’s search experience validates that participants gained skills to define search option and queries, and people who understand how to refine search queries through quotation marks and multiple terms in a query will end up getting effective Internet search results (Hargittai, 2003).

In the third action research workshop, the students were grouped and asked to reflect on problems they faced in using any of the five tools they had been introduced. In one of the group, using Google Docs came up as a problem for which they identified solutions, which a group member Soumya shared as: Open Google Docs… you need to create a new document. You have to click the share button. You need to click on the ID of the shared person.

Representing group one in the third AR workshop, Deepa shared with the whole group that: Concerning Google Docs, we had discussed two problems. Problems identified were confusion on how to save and how to share the document ” Solutions discussed on how to save when the person who the file is being shared with is editing. Just see when the editing is done …wait for some time and then save… Confusion in sharing the document – click on share; enter the email ID of the person whom you want to share with, then it gets shared automatically.
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The solutions that the students came up with for the problems identified show that they were able to define the information problem and were also able to take the right action.

In the third action research workshop students’ reflection showed how they have got a knack of using Boolean search strategies.

Reshma stated in the third AR workshop that: *what you need to keep in mind is … type the correct word…when you search for a topic type short keywords… put the words in inverted commas and give conjunctions like ‘and’.* Reshma was a student who did not know anything related to Internet prior to the research intervention. What was also observed was her improved confidence level while she explained the significance of using Boolean operators to the whole class.

A similar reflection was also identified in another group in the third AR workshop, where Soumya reflected that *we discussed that we should try to use the keywords for searching… and using Boolean words like ‘and’.*

Students in both groups had discussed using Boolean operators for getting efficient results that shows their improved searching expertise. The literature states that one of the main problems related to Internet search skills is the formulation of unsuitable and overly general search queries and lack of knowledge about using Booleans (van Deursen & van Dijk, 2009). The use of Boolean operators and Boolean logic are associated with searching expertise (Edwards & Bruce, 2002; Hargittai, 2003). Thus, the students gained knowledge on Boolean operators that can refine their search bringing better search results.

Student’s reflection also showed improved Internet self-efficacy, which is their confidence in their ability to use the Internet, reduced technophobia, which is the fear of using the Internet.

Deepa reflected in the fourth AR workshop: *I got to know many techniques to search and find information fast. Got to know tools . . . I feel that my speed in using the Internet has improved*.

Jasna’s reflection in second and fourth action research workshop showed how she has gained the confidence in using the Internet:

*It’s the first time that I am doing a PowerPoint. I still have confusion on how to format, how to put pictures, I feel that still, I do not know much . . . on how to take and where to click and all, and I don’t have enough speed to do the Internet search . . . but feel that I know some information and how to perform an Internet search much than before. But I would like to know more about the Internet . . . and I would like to do my seminar presentations in PowerPoint.*

What she expressed in the fourth AR workshop was, *Compared to before I can say there has been a lot of improvement. Earlier it was difficult typing my name even. I can type my Gmail ID. See . . . I did not even have a Gmail ID before. I don’t think my usage is good enough, but I am really interested to use it now since I know now and would like to use it in future and improve my usage.* Her reflection shows that even though she does not consider herself an expert as she does not believe that her skills are good enough, but her Internet efficacy has improved through the skills she gained through the training and workshops, which she feels, will be useful in the future.

In the fourth action research workshop, Tahira not only reflected on the element of reduced technophobia for using Internet but also included that her fear of visiting an Internet café had reduced: *I have never gone alone to a public center [Internet café]. I have not used the Internet alone… was doubtful if I could. I had only little knowledge about the Internet, but still had a fear of using it and had confusions. Now that has changed… I have that confidence and my fear has reduced.*
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Bindu and Reshma expressed their perceived ability to use the Internet as follows. Bindu’s confidence was reflected in the second AR workshop: *I did not even know how to search. But I am bit confused still on how to take printouts. But I do feel a change after the training and workshops. I know how to search. If I get a seminar topic, I know how to go to the Internet and search for information.*

Reshma expressed in the fourth AR workshop: *I can see that a lot of improvement has happened...like before I never knew anything. Now I believe myself that I can do searching...and have the confidence that I can go and look for things in the Internet...like going to a website and all.* For Reshma, who did not have any prior knowledge of using the Internet, her efficacy beliefs concerned going to an Internet and searching for information from websites. Bindu also gained confidence and expressed that now she knows how to search. Reshma’s and Bindu’s statements thus show improved Internet efficacy when they talk about their ability to take information from the Internet.

Knowledge level was also reflected through a questionnaire where the questions were about the knowledge on tools introduced before and after the workshops. With respect to Google searches, four students said they had used Google and four said that they had heard of it but not used it. Six of the students had not heard of a Boolean search before, and one student said she had heard of it but not used before, and one said she has used it. Four students had not heard of Google Books, and three stated that they had heard of it but not used, and one said she has used it. Google Scholar was also unfamiliar to five students and three said that even though they had heard of it, they did not know how to use it. Five students said that they had heard of an email ID but not used it, which means they did not have an email account, while two said they had used an email ID, and one student identified herself as an expert in using email IDs.

Seven of the students had not heard about the bookmarking site Delicious, while one said she had heard of it but did not use it. Three students did not use MS Word even though they had heard about it; another three said they had used MS Word and one stated that she was an expert. Google Docs was unfamiliar to six of them, and two said even though they had heard about it they did not use it. There was no one in the group who had not heard of MS PowerPoint. Two said they had heard of it but did not use it, as they did not know how. Five said they had used it, and one stated she is an expert. Six of them stated that they had not heard of Google Maps, while one student said she did not use it even though she had heard of it and another said she had used it. All eight students stated that they had not heard of Mindmeister and Google Forms. Six stated that they had not heard of Google Calendar, while two stated they had heard of it but did not know how to use it. Twitter was not familiar to four students, while the other four had heard of it but did not know how to use it. Two students had not heard of blogs before, and while six of the students had heard of it, they did not know how to use it. These findings provided a clear picture of the students’ familiarity with and usage level of the tools that they were introduced to. An overview of the knowledge levels before the intervention will illustrate how they have changed in terms of usage after the training and workshops.

Students stated on the improved knowledge level in using the tools introduced through the research through the questionnaire. Learning to use Google search, Email ID, Blogs, Google Maps, and the non-Internet applications such as Word and PowerPoint brought significant improvement in the knowledge levels for six students after the training and workshops. Seven out of eight responding students reflected that they had gained a significant improvement in knowledge levels in learning to use Twitter. Seven of the students felt that there was only some improvement in their knowledge levels as regards Google Books and Google Calendar. The significant aspect is that only one student said there was no change in knowledge level in using Delicious and one who stated that using the Word application did not bring any knowledge change for her. She was one of the students who had a computer and Internet connec-
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Ation at home and who was familiar with using the Internet. It was not expected that students could be made experts, but that they should know how to use the tools also after the workshops and training were completed.

Knowledge levels were also reflected through the empowerment indicator questionnaire that was given to students at the end of the workshops. In the questionnaire data, all nine responding students stated that their knowledge levels and skills had improved. The questionnaire was given to students again one and half year after the workshops and training were conducted through the research, and all the students stated that their knowledge and skills to use the Internet had increased.

IMPLICATIONS OF DEVELOPING INTERNET SKILLS FOR CREATIVE LEARNING ENVIRONMENT IN THE FUTURE

ICT makes possible asynchronous learning; learning characterized by a time lag between the delivery of instruction and its reception by learners and have accentuated the need for creative thinking (Zhou & Purushothaman, 2015). Internet based technologies is redefining the learning, transforming how students learn in traditional learning environment and making more learner oriented giving them the opportunities to learn what they want and how they want from where they want. Developing the Internet skills of the students is very imperative for learning environments in the future as Internet technologies provides the scope for varied ways of learning and creativity. The new age Internet technologies when used appropriately can foster the creative learning of the students individually as well as in group. There is an identified need to address the second order divide in skills of the students to enable them to efficiently participate in the information economy (Purushothaman, 2013). If the students do not have the skills to use the Internet, they cannot make use of the new age creative learning opportunities. Blooms digital taxonomy can be an effective method to make the students learn how to use the Internet so that they can use the new age Internet tools and technologies to enhance the creativity in learning.

The focus of Bloom’s digital taxonomy is on the thinking skills necessary to use the Internet rather than the content of the Internet. Focusing on the reflective approach to take out the information from the Internet is a life long skill that they can make use in future endeavors of life. This approach to training contributes to the field of Information Communication Technology for Design (ICT4D) to bring more effective results for projects that are based on helping participants learn to use the Internet, where the focus is on how the participants are learning to use the Internet thus acquiring a lifelong skill rather than focusing too much on the content of the Internet which is dynamic and which changes with time. Bloom’s digital taxonomy can help scholars and project managers have a common learning goal for participants in the study. It also allows for choosing the Internet activities for learning from the least complicated activities to the more complex activities as the participants’ learning progresses.

CONCLUSION

In today’s times when ICT is play a significant role in the enhancing the creativity of students, it is very imperative if students across the globe are getting equal opportunities to make use the ICT tools. Focusing on imparting the digital skills of students especially Internet skills is very important so that it gives the opportunities to use these tools creatively to augment the learning and creativity. Learners of this
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generation and coming generation has to be prepared for the evolving knowledge economy and making them equipped with the digital skills is of utmost importance if they need to be successful and move forward in the digital age. Some students by the virtue of their ethnicity, region, and class are not able to participate in this information age, as they do not have the scope of access in terms of requisite skills.

In any developmental research, field studies play a significant role in achieving the developmental outcome through interventions in real life situations. How an intervention is designed does influence the success of the project. In this research context the training for giving Internet skills for the students was designed based on Bloom’s Digital Taxonomy, providing a novel perspective to the training programs for students coming from underprivileged backgrounds and where majority were novice users. The focus of Bloom’s digital taxonomy is on the thinking skills necessary to use the Internet rather than the content of the Internet. This approach to training contributes to the field of ICT4D to bring more effective results for projects aimed at imparting Internet skills to the participants, where the focus is on how the participants acquire the conceptual and reflective skills in searching and retrieving information and using the Internet, thus acquiring a lifelong skill, than focusing too much on the content of the Internet which is dynamic and become irrelevant with time. Bloom’s digital taxonomy can help scholars and project managers have a common learning goal for students in the research and aid in making the Internet learning more organized and to track the learning outcomes. It also allows for choosing the Internet activities for learning from the least complicated activities to the more complex activities as the participants’ learning progresses.

Even though there is lot of focus on bridging the digital divide in terms of infrastructure and connectivity, the focus on addressing the second order divide especially, requisite Internet skills to make use of the available technology is very much missing in developmental research. Much attention needs to be done to address this issue, especially the younger generations Internet skills who are left behind because of lack of adequate skills to make use of the available access and become participants in the knowledge economy, which is driving the world. Opportunities have to be provided where in the students can have direct engagement with learning and using the various Internet tools and applications and also for sharing the learning experiences with in the group by making learning more engaging. The design approach of intervention used in this research can bring the desired developmental outcome as it can help the students become more involved in the training program making them more motivated to use the Internet even after the intervention, than a traditional technical-oriented training.

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**KEY TERMS AND DEFINITIONS**

**Creativity:** Development of original and innovative ideas.
**Digital Divide:** Differences in the access and usage of technology across people.

**Internet Café:** A public place with computers connected to the Internet where people can access and use the Internet where they will be charged on an hourly basis.

**Internet Self-Efficacy:** Confidence in one’s ability to use the Internet.

**Internet Skill:** The reflective and conceptual skills needed to engage and take out the relevant content from the Internet.

**Second-Order Digital Divide:** Differences in access and usage of technology among people when there is scope for access.

**Technophobia:** Fear of using the technology/Internet because of anxiety and helplessness when interacting with the particular technology.
Section 5

Reflection and Conclusion
Chapter 21
Framing Creative Problems

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ABSTRACT
Problems are a type of situations that are mentally and socially framed to direct efforts and resources with the aim to change them into desired future situations. The definition of what constitutes a problem, and particularly one worth solving creatively is often left implicit in research studies and professional practice. This chapter presents “Creative Problem Framing” (CPF) as a strategic part of the creative endeavor. It does so by analyzing a collection of projects that the authors have supervised in recent years in academia, start-ups, and industry in four countries. An analysis of these cases provides an initial set of dimensions of creative problem framing. The chapter ends with guidelines for higher education to promote creative problem framing, and to design studio-based experiences that enable learners to practice CPF in meaningful ways.

INTRODUCTION
There is a big problem with the word “problem” in the context of creativity. The word “problem” is used in everyday conversations, the media, and in academic and professional settings. A thesaurus lists the following related terms: complication, dilemma, dispute, headache, issue, obstacle, question, trouble, disagreement, doubt, and predicament. All these words carry a negative tone, signaling adverse situations which call for attention in order to imagine more desirable future states. This is in fact an influential definition of the concept of “design” in the academic literature (Simon, 1996), i.e., the course of action aimed at transforming undesirable existing situations into preferred future situations. One of the first difficulties arising from this definition is how may a problem-solver start to define what makes a situation undesirable. Inasmuch as design is a servicing activity, existing situations are characterized by/with
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others within their particular contexts—in other words, problems exist when they are identified as such by someone. This is substantively different from a commonplace understanding of problems existing "out there", as if they were objective constructs waiting for people to spot them as such. This is a key distinction because creative problem-solvers learn to approach situations in radically different ways as they understand that their creative efforts start, and are fundamentally determined, by framing problems.

The practice and research of creativity has heavily relied on the study of how different people generate ideas to solve a given problem. This constitutes a significant weakness in the pursuit of defining and evaluating creativity, since giving people a pre-defined problem inevitably leads to the enforcement of such particular framing in the problem-solving phase. After all, the comparison of ideas provided by different individuals or teams is only feasible when they tackle the same problem, and this problem remains unchanged in the solving process. However, highly creative solutions often transform the ways in which the problem are viewed—i.e., patent claims must demonstrate non-obviousness or being different from "an obvious extension or adaptation" of current practice (Simonton, 2012). This approach is equally prevalent in professional practice, where problem solving starts by the fairly reasonable step of "defining the problem". The authors have observed over the years a natural tendency of students, entrepreneurs, practitioners, and government officials to view problems as well-established constructs, i.e., the parking problem, the obesity problem, etc. In the rare cases when the problem-solver does acknowledge that problems are identified, framed, and defined by someone, this is accompanied by a belief that such framing process is not their responsibility. For example, designers often ascribe the role of problem framing to the marketing department, to higher management, or to the client.

Viewing problems as undesirable situations entails that they are mental and social constructs (Volkema, 1983). Hence, defining a problem means defining what makes a situation undesirable and what are its causes and consequences as viewed by the problem-solver as an individual and as a member of her sociocultural context. Such definition shapes the problem and directs problem-solving to focus on factors deemed as relevant and to ignore those viewed as ancillary. In a way, our world is in fact organized in a largely arbitrary (and heavily influenced by past realities) organization of reality into problems. The futility of such structural divisions becomes clearer when so-called “big problems” such as Climate Change are considered: whose problem are such complex and high-priority problems? But even in more concrete, tangible, and everyday situations, such as transportation or housing, it is worth questioning who owns the problem, as ownership carries the responsibility of framing the problem. Experts are habitually granted ownership based on their disciplinary or professional ascription, but there is no natural, objective, or definite way to bind a problem to an area of expertise. People who are directly and indirectly affected by these situations clearly own the problem too, and the main challenge is that in such multitude of stakeholders, each of them brings different and often incompatible needs and desires to the way a situation is characterized. Consequently, problems are shaped by a vast number of formulations of reality—an array of situations deemed as undesirable by many people, and not necessarily for the same reasons.

Furthermore, in a dynamic world, conditions are constantly evolving and so situations mutate over time, a simple truism that most people neglect, as eminently pointed by George Bernard Shaw: “the only man I know who behaves sensibly is my tailor; he takes my measurements anew each time he sees me. The rest go on with their old measurements and expect me to fit them.”

This chapter re-examines conventional views of problems in the context of creativity, and the misleading notion that problems can be “solved” creatively. It is argued here that problem-finding and problem-framing are more appropriate and relevant issues to focus in the study, practice, and teaching of creativity. The chapter continues with a review in Section 2 of key ideas from the literature. In Section 3
the framing of problems is analyzed by considering a collection of fifteen cases where the authors have been directly involved. These cases illustrate a wide diversity of reframing processes. A specific case is described at length, inspecting in detail ten dimensions of problems reframing. The chapter ends with a discussion of the pedagogical issues needed to support the development of Creative Problem Framing (CPF) in Higher Education.

BACKGROUND

In contrast to “tame problems”, their “wicked” counterparts are considered to be non-deterministically polynomial, open-ended, time-dependent, ill-defined, and including negotiable constraints and incomplete, contradictory, and changing requirements (Rittel & Webber, 1973; Goel, 1995). In other words, the specification or definition of wicked problems is always incomplete and undeterminable, because the initial and the end states are ambiguous, and the information to connect both is insufficient (Buchanan, 1992). This distinction, also qualified as “reasonable” and “unreasonable” problems (Perkins, 2000) does not mean that there are problems out there that are wicked per se. As explained above, the wickedness of a problem is established (often implicitly) by those who frame it. As obvious as this seems, mainstream practice today still contradicts the key notions that problems in creative practice cannot be fully determined, its framing is bound to change during the solving phases, and there is no single correct answer. For example, the Organization for Economic Co-operation and Development (OECD, 2012) includes a “Creative Problem Solving” test in the Programme for International Student Assessment (PISA) that visibly illustrates how problems are customarily viewed in creativity.

The “PISA First Assessment of Creative Problem-Solving” (OECD, 2012) was administered to 85,000 students in 44 countries, aiming to build “an assessment of student performance in creative problem solving, which measures students’ capacity to respond to non-routine situations” (pp.51). Problem-solving competence is defined in that test as: “an individual’s capacity to engage in cognitive processing to understand and resolve problem situations where a method of solution is not immediately obvious” (page 30). Notwithstanding the restricted view of creativity to an individual ability (Sosa & Gero, 2016), most relevant to our discussion here is the ensuing description that problem-solving begins “with recognizing that a problem situation exists and establishing an understanding of the nature of the situation. It requires the solver to identify the specific problem(s) to be solved, plan and carry out a solution, and monitor and evaluate progress throughout the activity” (OECD, 2012, pp. 30). The description by the education experts in charge of this authoritative assessment is unequivocal: creativity starts with problems that exist and the task for the problem-solver is to adequately identify them in order to plan and carry out a solution. This is far from a rare event; a prominent review of brainstorming research found that the way tasks were framed across fifty studies in four decades was inconsistent with appropriate creativity guidelines (Isaksen & Gaulin, 2005).

Tame problems (fully specified, and where both the initial and the end states are fixed) are not appropriate for the study and practice of creativity. Problems suitable for creativity, or “creative problems” have initial states that are undetermined, the operations are not explicit, the end goal is ambiguous, and there are multiple possible solutions, some of them are more appropriate than others for a given problem framing. The PISA test provides the following example of a typical problem in the test: “consider the problem of determining whether a lamp is not working because a) the switch is malfunctioning, b) there is no power, or c) the light bulb needs to be changed. Although the situation might be familiar to
Framing Creative Problems

many 15-year-olds, few students, if any, have had the opportunity to develop expertise in this class of problems, and the unique design of a test unit around this problem situation makes sure that at least some adaptation of ready-made strategies is needed.” (OECD, 2012, pp. 30). In this case, the starting point is clearly defined: an undesirable situation of a lamp not working, and the end point is equally clear: the desired situation of a working lamp—implicitly defined as its lightbulb emitting light.

Aiming at the wickedness of creative problems, such diagnosis task could be reframed in a vast number of creative ways, for example: How can a lamp work better? What can a future lamp be like? What is wrong with lamps today? What are lamps for? What is a lamp? How else could future lamps work? How are current lamps not working? Who needs light, where, and for what? These questions are still quite specifically about a lamp, yet neither the starting point nor the end result are defined, and they go beyond diagnosing a faulty device. Notice that simplistic framings that do call for divergent reasoning but deviate from the problem at hand are avoided, i.e., “What alternative uses can you find for a lamp?”.

Creative problems should categorically allow for openness but maintain focus. Consider in this context an idea such as “Gravity Light”2, an illumination device that generates light from gravity, a response to a challenge that seeks to eliminate kerosene lamps since an estimated “780 million women & children breathe kerosene fumes equivalent to inhaling 40 cigarettes a day”—according to their website. Once fumes, cost, risks, and environmental impact are framed as the factors behind “a lamp not working”, the solution space is undetermined and the stage is set of truly creative solutions.

Defining a problem in the initial phase of problem-solving is pervasive across toolkits and frameworks of creativity and design, many of which fail to include explicit criteria or mechanisms to revisit the problem definition at a later stage, and instead proceed linearly from defining to solving the problem. One of the earliest models of creativity is the four-stage model or the Wallas model, which remains cited across the literature despite the evident criticism that “such an analysis is very superficial (…). It tells us almost nothing about the mental operations that actually occur” (Guilford, 1950, pp. 451). The initial “Preparation” stage is described as a preliminary analysis, defining and setting up the problem (Lubart, 2001). This is followed by unconsciously working on the problem, a process called “Incubation” that precedes a flash of sudden enlightenment in “Illumination”. Finally, in “Verification” a deliberate process involves evaluating, refining, and developing an idea. Although the model does account for iteration, works citing the Wallas model seldom account for “Illumination” applied to the problem definition.

In education, Problem-Based Learning (PBL) and Project-Oriented Learning (POL) represent a variety of hands-on active learning approaches where a uniform problem definition is prescribed to learners, i.e. “At the start, students are offered a unit guide, which provides them with information about scheduled activities, an introduction to the unit’s theme, a set of problems and a list of references and other learning resources (…) students discuss practical or theoretical problems designed by staff” (Moust et al., 2005, pp. 666). Similarly, teaching design in engineering shares this starting point with PBL and POL: “Both start with an identified problem or situation which directs the students’ area or context of study” (Mills & Treagust, 2003, pp. 4). The prescription of a definite problem set is consistent across education approaches based around problems or projects, precluding true openness in favor of standardized paths of syllabus design and assessment.

The “Design Thinking” (DT) method consists of five stages, with “Discovery” as the departing point from “a specific and intentional problem to address; this is called a design challenge (…) Finding opportunities for design often comes from noticing problems (…) Make a list of all the problems you’ve noticed or things you’ve wished for” (IDEO, 2012, pp. 19). As a starting point, the authors agree with the general recommendation to jumpstart the process with an opening statement, and the DT method
does mention the advantages of iteration. However, DT fails to explicitly articulate means to reframe the design challenge at later stages, and in practice, the authors have observed people trained in DT oblivious of the importance of maintaining problem discovery active throughout the process. Moreover, DT instructs in the “Discovery” stage to “sketch out end goals. Define your goals for undertaking this design challenge. Be honest about determining a realistic scope of your project both regarding time and output. What will you work to produce? Where do you expect to get at the end of this process?” (IDEO, 2012, pp.19). With a definite definition of a fixed end state, DT is more appropriate to tackle tame rather than wicked problems, and its relevance for creativity is questioned (Sosa, 2015).

Design problems are considered wicked, and it is widely accepted that whenever a design brief does prescribe “in great detail the particular features of the product to be planned, it often does so because an owner, corporate executive, or manager has attempted to perform the critical task of transforming problems and issues into a working hypothesis about the particular features of the product to be designed. In effect, someone has attempted to take the “wickedness” out” (Buchanan, 1992, pp. 17). In contrast, the role of designers is considered to be to shape situations and identify “the views of all participants, the issues which concern them, and the invention that will serve as a working hypothesis for exploration and development” (Buchanan, 1992, pp. 17). This process of nominating a provisional framing as a way of approaching wicked problems, is considered an appropriate heuristic to support the co-evolution of problem and solution, i.e., the dialectic interaction that mutually shapes how a design problem is understood and the range of solutions that are possible (Poon & Maher, 1997; Dorst & Cross, 2001). An iconic example is the Sydney Opera House, where the rules of the competition had to be modified in response to the advantages offered by the winning solution. This is today considered a paradoxical principle of architectural competitions where “jurors need precise evaluation criteria set on advance in the competition brief to ensure fairness in decision making, but at the same time they ask for flexibility in assessing the entries, because entries can reveal new unplanned insights into the competition’s problems” (Manzoni, 2015, pp.190).

FRAMING AND RE-FRAMING DESIGN PROBLEMS

The notion of problem and solution co-evolving entails that creative problem-solving is not a linear process of starting with a phase of problem finding followed by framing, then solving a problem. Rather, any given problem framing remains in a provisional or temporary state throughout the problem-solving process. Creative problem-solving may indeed commence from definite specific verbal statements, but it views problems as departing points in a journey to creatively unfold the situations. A balance is achieved with the framing of creative problems that enable action but that are constantly questioned and challenged. This relentless questioning of what the problem is, does not seek to verify a hypothesis, but rather has the aim of learning. In this journey, the problem-solver transitions from a “We are (obviously!) solving this problem” to “We are (tentatively) tackling this situation in this particular way as a means to probe and learn more”. This type of re-framing a problem is a key goal of creative processes, so much so that the most appropriate unit of analysis in the assessment of creativity may be the novelty and utility of the shifts in problem framing, rather than of the solutions generated.

An explicit process of re-framing tame problems, or un-taming situations is necessary to bring their wickedness out. In such process, the myriad issues involved are constructed, the stakeholders and their latent needs are revealed, and unexpected ideas arise from operations such as interviewing, observation,
Framing Creative Problems

simulation, or prototyping (Sanders & Stappers, 2012). Insights are framed as a result of such process, often leading to a substantial revision of the initial assumptions, boundaries, and understanding of what constitutes undesirable and desirable situations, and for whom. In the example provided by the PISA test described in the previous section (Why is a lamp not working?), and the creative re-framings suggested (How can a lamp work better? What are lamps for? How are current lamps not working?), high complexity is revealed when considering the sourcing of the materials selected to manufacture each component, to assemble the lamp, and to the global system of distribution. A better understanding of what it means “to work” in the context of a lamp emerges as problem framing is informed by problem solving, for example, the shifting daytime/night-time behaviors, the conditions of power generation and distribution, the design of the built environment where artificial light is required, the capabilities of the users, the evolution of current tasks and relationships around light and everyday devices. This practice has been a standard way of practicing design as captured by the architect Gottlieb E. Saarinen a century ago in the well-known aphorism: “Always design a thing by considering it in its next larger context – a chair in a room, a room in a house, a house in an environment, an environment in a city plan.”

A collection of fifteen cases is extracted from the authors’ teaching and consulting experiences in Singapore, New Zealand, Mexico, and the United States. Table 1 shows the original problem framing in the second column as initially described by the problem-solving teams, and the revised creative problem reframing in the third column. The insight driving such shift in problem framing is provided in the fourth column. These projects range in time from a few days to months, and include undergraduate, graduate, industry, and entrepreneurial projects.

These fifteen cases suggest a diversity of issues and related strategies for creative problem framing (CPF). The following ten CPF dimensions are extracted from this collection:

Initial Framing: The early stages of a project where the problem is initially addressed can play a role in how it is possible to reframe it in future stages of the project. When problems are explicitly defined by a client or stipulated by an authority in a design brief or a competition brief, subsequent reframing by third parties is likely to encounter resistance. In contrast, problems that invite reframing are those framed in open and flexible terms in the design brief, for example the 2015 James Dyson Award invites inventors to: “Design something that solves a problem” 3. Another possibility in CPF is that no specific problem is defined as a starting point, but instead projects are framed thematically or with a target location or population, allowing the problem-solvers to scope for relevant and interesting problems. In many of the cases listed above, the teams changed not only the problem framing, but also the name of the project as the problem evolved over time.

Source of Insights: Reframing may originate from any of the activities that are part of the problem-solving methods and techniques, ranging from interviews, observation, generative co-design sessions, etc. It may also be the case that CPF appears as a “Eureka” moment or a sudden insight that problem-solvers develop over time after what is customarily called an incubation stage, i.e., subconscious processing. Insights can also be articulated by third-parties, for example experts or lead users, and arguably one of the most important skills of a creative problem-solver is to facilitate such creative and reflective processes in people who are more familiar and experienced with the domain and context of the situation being tackled.

Degree of Change: A creative reframing may redefine the task in terms of changing the target user, the technology, or a number of other issues originally considered to be critical. Some instances of CPF may consist of rather subtle realignments, but it can also be the case that reframing the problem


Table 1. Fifteen selected cases showing the problem as originally framed, the ensuing re-framing, and the key insights that support the re-framing of the problem.

<table>
<thead>
<tr>
<th>Case</th>
<th>Initial Problem Framing</th>
<th>Problem Re-Framing</th>
<th>Key Insight</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Redesign light poles to stop street hawkers from stealing electricity from public utilities.</td>
<td>Examine a new business model to provide safe and on-demand mobile electricity to people in public areas.</td>
<td>Through interviews, observation and prototyping, the design team realizes that street hawkers are willing to pay for safe and convenient power, since today it is risky and costly (in bribes, fines, and repairs). An increasing variety of users that need to power their devices on the go are also identified as potential future users.</td>
</tr>
<tr>
<td>2</td>
<td>Design and build a classroom-on-wheels to house a mobile computer lab where children can learn about recycling.</td>
<td>Design and build a learning playground in a bus with interactive and physical displays where children can play and learn about sustainability.</td>
<td>The design team finds an opportunity through observation and prototyping, to create memorable extra-curricular experiences where children are active physically and learn through play.</td>
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<td>3</td>
<td>Visit remote indigenous communities to transfer product design skills that help them improve how their handcrafts are made.</td>
<td>Develop a dialogue and long-term partnership with remote indigenous communities to build synergies that help increase the value of their hand-made crafts.</td>
<td>Ethnographic research shows that traditional cultures are rich and unique, their knowledge and beliefs are cultural treasures that are in constant flux. The problem of low quality and poorly designed handcrafts is systemic and starts with what (urban middleclass) customers expect and how they perceive hand-made artefacts.</td>
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<tr>
<td>4</td>
<td>Design a smart ring that vibrates to help blind people walk in urban areas.</td>
<td>Design new types of wearable devices that help people schedule, manage and perform daily tasks better.</td>
<td>Prototyping early devices shows that wearable devices can convey information in unobtrusive ways (vibration), and opens the door to new applications that do not require screens and consume low power.</td>
</tr>
<tr>
<td>5</td>
<td>Design a new range of “Social Robots” that assist users in everyday environments (home, offices, hospitals, or schools).</td>
<td>Design “Robot-Inclusive” everyday environments.</td>
<td>Consultation with experts across disciplines show an opportunity to connect design decisions across robotics experts and designers of spaces and furniture to optimize their integration, opening new applications for “Social Robots”.</td>
</tr>
<tr>
<td>6</td>
<td>Design innovative sex toys</td>
<td>Improve communication between sexual partners to improve their shared understanding, consent, preferences, and improve their intimate life.</td>
<td>Interviews and generative design workshops with users and experts challenge initial assumptions about the physical dimension of sex toys and inform the design team that communication plays a key role in the quality of sexual life.</td>
</tr>
<tr>
<td>7</td>
<td>Create a car-pooling app to reduce the environmental footprint and ease parking problems in campus.</td>
<td>Car-pooling has a number of unobvious consequences and nuances that make it difficult to translate intention into behavior.</td>
<td>Through embodied brainstorming and prototyping, the design team reveals a collection of issues that prevent people from offering and taking rides with acquaintances and other members of the community (privacy, gender, social, health, perception of fairness, and trust).</td>
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<tr>
<td>8</td>
<td>Design an app to help students locate their teachers outside lectures.</td>
<td>Design hands-on learning toolkits that students can borrow to prepare before lectures, or practice and re-examine the main concepts or skills of the week.</td>
<td>Through interviews with teachers and students, a detailed typology of students is built based on how they perceive the need to contact their teachers outside lectures. Alternative kits are tested resulting in new criteria for the design of educational materials that support various learning pathways based on autonomy and collaboration.</td>
</tr>
<tr>
<td>9</td>
<td>Design a human power charging station for mobile devices at music festivals.</td>
<td>How do people interact with each other at music festivals and what draws them together in groups?</td>
<td>Testing of early prototypes indicates that people would rather spend time in more social engagement activities than to power their mobile device at music festivals.</td>
</tr>
<tr>
<td>10</td>
<td>Design a skateboard developed using waste timber.</td>
<td>Investigate methods to upcycle and reuse plastic bottles to create products without the need for recycling.</td>
<td>Whilst timber is large proportion of landfill, unless it is treated, then at least it is biodegradable. In contrast, plastics take hundreds or thousands of years to degrade and whilst using plastic is more challenging, it is more sustainable.</td>
</tr>
</tbody>
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Continued on next page
Framing Creative Problems

Table 1. continued

<table>
<thead>
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<th>Problem Re-Framing</th>
<th>Key Insight</th>
</tr>
</thead>
<tbody>
<tr>
<td>11</td>
<td>Develop a programmable electronic t-shirt to initiate conversations for shy people.</td>
<td>What makes shy people comfortable and confident to start a conversation with someone? Can shy people be identified and supported?</td>
<td>The need for power supplies and electronics limits the extent to which any such t-shirt can be comfortable to wear which may result in less capacity to maintain a conversation due to lack of comfort.</td>
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<tr>
<td>12</td>
<td>Design a “sleeping pod” to help students take a nap in campus.</td>
<td>Rethink building design, class schedules, open and flexible learning workspaces, and all dimensions of campus life to help students adopt healthy study and sleep habits.</td>
<td>Through interviews and virtual models, users articulate a range of concerns about using “sleeping pods” in campus, and identify an unexpectedly long list of causes of their tiredness during the day.</td>
</tr>
<tr>
<td>13</td>
<td>Design a respiratory mask for children to be used during periods of high air pollution (haze season) in Singapore.</td>
<td>A variety of mask designs for children already exist, but wearing habits make them ineffective. Testing revealed problems with thermal discomfort, poor fit, self-image, and a high degree of individual variation.</td>
<td>A host of start-up companies exist across Asia developing and testing respiratory masks for children. Designing a device to tackle the symptoms is deemed less fruitful than to develop sustainable alternatives to palm oil production, which causes the slash-and-burn malpractice of tropical forests.</td>
</tr>
<tr>
<td>14</td>
<td>Design structural sound barriers and relocate, revise, reschedule and eliminate daily program activities in response to ‘noise complaints’ from neighbors of a semi-rural environmental education camp.</td>
<td>Design a neighborhood outreach initiative to explain the camp’s mission, program, schedules, activities and outcomes – discover volunteer mentors and additional financial support for the camp’s programs.</td>
<td>‘Noise’ - ‘any disagreeable, unexpected or undesirable sound’ - initially interpreted as a physical issue, dictates a costly, disruptive physical response. ‘Noise’ understood as an emotional issue, however, allows addressing the neighbors’ perception of camp activities - shifting it to agreeable and expected. This minimizes program changes and increases available resources.</td>
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<tr>
<td>15</td>
<td>Declaring her daughter’s room ‘a mess’, a mother demands that her daughter clean her room immediately. The daughter adamantly refuses. A pitched battle ensues.</td>
<td>The mother and daughter design a ‘safe space’ for mutually important information - which clothes are dirty and which papers need to be reviewed and returned to school.</td>
<td>The mother equates ‘mess’ with ‘chaos in her daughter’s life’. To test this, a friend suggests she relocate two objects in the ‘mess’. The daughter easily detects the changes, proving an order in her room - albeit one inaccessible to her mother. They then agree on mutually important information and design a system to safeguard it.</td>
</tr>
</tbody>
</table>

reveals unexpected users, or new opportunities that cause a significant detour from the initial route. The latter resembles what is called in entrepreneurial circles as “pivoting”, or learning from early feedback from the market and making substantial changes to the value proposition. Intrapreneurship and spin-offs are examples of major problem reframing, which may include changes to the core activity of organizations.

Clarity in New Direction: One possible outcome of reframing is that the problem-solvers become aware that the original problem description fails to lead to creative and feasible solutions, but no promising leads are visible. Such projects tend to be terminated or shelved until a more unambiguous direction can be determined. The selection in Table 1 is biased towards cases where CPF led to clear novel directions—the list of cases experienced by the authors where insights showed the problem-solvers the frailty of their initial assumptions but failed to provide a way forward is many times longer. A critical “valley” exists between retrieving and transforming adverse feedback into insights that lead to creative re-framings. Team morale, leadership, conflict, and discouragement
are some of the high-risk factors during such periods –particularly if unsuitable expectations are held. Perseverance is valuable to overcome such challenges, as well as the continuous debriefing and re-examination of data. Adopting a pre-expert disposition is critical in CPF to relinquish the safety carried by experience and mastery. The exasperation of “feeling lost” can be an indicator that valuable insights are about to emerge in the process.

**Changes in Ownership:** A contentious possible outcome of reframing has to do with power structures, egos, and ownership. Reframing that leads to such changes are the hardest since they may require an entire redefinition of who solves the problem –and who takes the credit. For example, an Architect may reach the uneasy realization from the requirements for a new residential project, that the client does not need help from an Architect as much as from a Family Counsellor. This critical point in CPF is illustrated by the creative collaboration between Jörm Utzon and Ove Arup in the critical period between 1958 and 1961 to develop a buildable solution for the roof of the Sydney Opera House (Murray, 2003). Utzon’s winning schematic design was praised by the judges of the competition in 1957, but construction of the foundations for the building began without a finalized solution for the roof. Over many months, Utzon and the engineering experts were unable to agree on a suitable geometrical solution that maintained the original design intent and at the same time allowed for structural analysis and cost-effective building solutions. Ultimately, the final modular solution of spherical segments for the “shells” entailed substantial changes to the original sculptural roof concept. Several indications suggest that such compromise was possible largely because the spherical solution came from the architect himself after a long and intense collaboration with engineering and mathematics specialists who had proposed a number of candidate solutions including paraboloids and ellipsoids that were rejected by Utzon (Murray, 2003). To produce the initial schematic design, it can be said that the Architect’s problem was originally mainly of an aesthetic type. In order to reach the final design, the problem was reframed to include structural analysis and construction.

**Range of Representations:** One of the most critical skills for creative problem-solvers is to be able to build and maintain multiple representations of the problems they tackle, and the ideas they produce. Multi-modal work in CPF integrates the use of written reports, freehand sketches, photographs, video recordings, and a variety of modelling and prototyping approaches. A key advantage of representing information and ideas in multiple formats, media, and materials, is that each representation affords different associations and interpretations. Creative problem-solvers are proficient in several techniques and communication formats, they gather a wide variety of life experiences and general interests, they are multi-cultural and widely read, and they are fluent in more than one language. Moreover, they keep a genuine interest in continuous learning of new tools, techniques, and technologies. These characteristics allow creative problem-solvers to switch between frames of reference, incorporate knowledge and intuitions from multiple sources, extrapolate and build analogies from distant domains, and combine ideas through connections that others fail to see.

**Detached Commitment:** Similar to how “chindôgus” in Japanese are paradoxically defined as useless inventions in the sense that they are rather unusable yet they respond to a real need, creative problem-solvers cultivate an ethos of being detachedly committed to the problems they solve. This essentially translates into an open attitude that drives swift neutral decision-making supported by evidence, whilst simultaneously the person or the team shows high motivation and enthusiasm for what they have set to achieve. A tension is obvious in such a conundrum for CPF: How can someone be passionate about developing a new technology (for example a mobile phone app), yet
at the same time eager to accept that said technology whilst appealing in the beginning, may not necessarily respond to the actual problem? The answer is that creative problem reframing fails to take place when problem-solvers are unable to let go their primary interest and decide to ignore the evidence and feedback that indicates that a different approach would be more appropriate. In our experience, detached commitment is best achieved when problem-solving is driven by changing an end goal state, rather than by a means to do something. In this respect, it is irrelevant whether such objectives are unselfish and altruistic, or profit-driven; what matters is that they provide a clear vision that guides problem-solving activity whilst allowing for radical changes in how to reach the dream. Creative teamwork is conducive to this type of flexible commitment.

**Learning:** The “fail fast, fail often, fail cheap” mantra popularized in entrepreneurial circles in recent years need not imply that all failure is positive. In CPF, failure is valuable insofar as it is transformed into a learning opportunity. In this sense, “productive failure” is necessary in creative problem framing as a relentless way of exploring speculative problem definitions, and as a result, asking “What can we learn from seeing the problem in that way?”. Very rarely do problem-solvers ask such simple question, yet asking it regularly and taking this process seriously does provide invaluable insights. For example, if the introduction of airbags in cars failed to reduce the rate of fatalities due to an increased incidence of car accidents at higher speeds, this should teach car designers and policy makers valuable lessons about approaches to safety in vehicles. In contrast, the trend has continued to increase the number of airbags in cars. When a solution fails to tackle the problem it was designed for, it is likely that the problem calls for re-framing. Whilst the airbag was aimed at reducing damage in a collision, it has likely caused a behavioral change in drivers who are inclined to drive at higher speeds (Vaa, 2007).

**Time:** Reframing problems is difficult to predict. The authors have witnessed CPF cases where reframing took a few days of full-time work, instances that took the length of a semester of studio work (12 to 20 hours per week), and still other cases where reframing spanned over several months, and up to five years to build and consolidate the reframing. CPF is an ongoing process, for example rapidly-evolving artefacts such as videogame consoles have undergone several cycles of reframing in the last decades where the definition of videogames keeps evolving. Similarly, wearable devices and 3D printers are in an ongoing reframing process with companies and users playing different roles in shaping the associated problems. In the case of the Sydney Opera House, several key design decisions triggered substantial reframing of design problems with the initial construction phase underway, i.e., the so-called “problem of the shells” (Murray 2003).

**Complexity:** A systems view is useful to discern feedback cycles, parameters, rules, delays, stocks, flows, and interactions, all of which can be candidate “leverage points” in CPF (Cardenas et al., 2011). Rich pictures and other mapping and visualization activities can help problem-solvers comprehend the limits of a situation, identify the root causes and scope the interrelated factors. Taking into consideration the historical trajectory and the contextual factors can lead to insights, as well as collaborating in multi-disciplinary teams where multiple views are combined. In the analysis of complex situations, problem-framing calls for a critical perspective of indicators, and particularly of an emphasis on quantitative metrics as articulated in the aphorism “you can only improve what you measure”. Nonetheless, analysis and synthesis are both essential in problem framing, and learning to transition between these distinct modes of thought can be challenging.
The collection of cases presented here is complemented with the detailed description of a design project that one of the authors co-led in the city of Bacolod in the province of Negros Occidental, The Philippines. The ten CPF dimensions extracted from these cases guide the reflection on that project.

**A $10 Toilet for the “Ultra-Poor”**

This project was funded by the International Design Centre of the Singapore University of Technology and Design from January 2013 to March 2014, as a part of “Opportunity Lab” (O-Lab), a design laboratory to study and practice design for social change in Southeast Asia. A partnership was established with two organizations, the World Toilet Organisation (WTO) and International Care Ministries (ICM) to tackle the problem of sanitation in communities classified as ultra-poor or “the poorest of the poor”, i.e., with a daily income of $1.25 or less. A group of half a dozen Engineering and Architecture undergraduate students volunteered to take part in this project, which started with a presentation by the director of WTO in campus, and continued with a series of weekly seminars led by the first author and Victoria Gerrard in O-Lab over four months to prepare the students for the fieldwork. WTO has extensive experience in the region (Cambodia, Indonesia, and India) deploying affordable latrines and toilets to improve the living standards of rural and poor communities. The problem as initially articulated by our partners was to design and build a $10 toilet for the ultra-poor of The Philippines.

Training for this project was conducted in participatory, empathic, and creative methods, finalizing with students demonstrating their ability to observe and interview people, and to interpret data. In May 2013 the group travelled to Bacolod where the ICM partners briefed them in relation to three communities enrolled in their “Transform” programs. The group was introduced to three “Pastors” who lead visits to three communities in and around Bacolod City: a small fishing village, a sugarcane Hacienda, and the urban slums. The group conducted interviews with various beneficiary groups and members of the wider community. As expected, adequate sanitary conditions were missing in the three communities, and a visible extreme poverty and lack of opportunities was witnessed across these groups. Reaching these groups via ICM was advantageous in many senses, particularly as the level of trust between the Pastors and the community is high, so the group of overseas students was able to rapidly establish rapport with members of the community, and conduct interviews and creative generative sessions to help articulate and reflect on the most pressing needs and latent opportunities.

Over a few days, the differences across the three communities became more evident, not only in terms of the infrastructure available and the natural conditions of the terrain and the surrounding environment: in the fishing village houses are built in stilts and its inhabitants are coping with devastating effects of climate change such as floods and rising sea levels; the Hacienda works around the harvesting of sugarcane and has more ample and less vulnerable living space; and in the slums people have access to more advanced infrastructure but also to the inconveniences of rapidly growing urban areas, such as pollution, extortion, and crime. Moreover, beyond the physical conditions, the social structures and historical trajectories of these three groups are significantly different, life for the fishing families is controlled by a powerful individual who owns all the fishing boats, buys all the fish, and also holds a monopoly over the provision of transport and goods sold in the village; in the Hacienda power has remained in the hands of one family since the days of the Spanish colonization, with children inheriting from birth the debts of their families; and in the slums social ties are weak since most people come from outside, and financially the group is controlled by a system of informal ‘loan sharks’ who patrol the slum armed to collect daily or weekly payments.
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It is in these challenging and highly complex environments with entirely foreign conditions for our group of Singaporean university students, that they were able to start grasping an understanding of the complexities of sanitation and its connections to gender rights, addictions, violence, debt, domestic violence, vulnerability, lack of self-determination, education, family planning, self-medication, and a myriad other hardships. However, the most surprising finding that the students highlighted in their visit report was a positive one: they witnessed an overall positive, optimistic, and happy attitude from the people living in these conditions, despite the significant disadvantages imposed by their environments and social realities. The group witnessed kindness, collectivism, and a strong sense of altruism in the communities, together with various social practices that are hard to find in the present reality of their own economically developed country. The group of students continued meeting on a weekly basis for the rest of the year, alternating discussions about their findings, learning from cases published in the literature, and sharing ideas with ICM via videoconferences.

The final report presented the students’ experience during their visit to Bacolod, and the ensuing change of how the problem was framed, as they identified that a $10 toilet was not an adequate way to approach the problems faced by these communities. The first indication came from a recurring finding from the group interviews and creative generative sessions showing that topics of sanitation had a low priority as a perceived need by members of these communities. A second clue came from evidence that a similar program had taken place years before in the Hacienda, where only a handful of houses had obtained the materials offered by the local government and they had built their own “water closet” and septic tank. Third, the social and the physical conditions of their environments in the three contexts are so different, that no one-fits-all solution can be relevant for these areas. Lastly, recent literature on the topic shows that behind the positive bias, most sanitation projects have failed to change behavior, i.e., building more toilets do not stop people from defecating in the open (Starkl et al., 2013).

The problem was thus re-framed by the group in terms of reinforcing, complementing, and extending the education and training programs such as those offered by ICM, but to design these programs in close consultation with each community and outside the scope of a religious organization so that people of different creeds could participate. The main goal in this second phase became one of identifying and empowering change agents in the communities with the long-term objective of building creative capacity, self-esteem, financial autonomy, reinforce social ties, and increase communication with other groups in Negros Occidental and the rest of the country. On their own initiative, the students planned and applied for funding for a second visit to share ideas with the Pastors and the communities.

Reflections on the “$10 Toilet” Re-Reframing

Initial framing: The goal to design and build a $10 toilet became the title of the project. This act of naming an initiative with an early problem definition is as customary as restrictive, i.e., the “$100 laptop” launched in 2005 changed its name two years later to “One laptop per child” (OLPC) when the technology requirements made such goal unrealistic. The OLPC may soon be renamed again, as their latest product is a tablet, rather than a laptop. On the other hand, an early clear focus did help in the case analyzed here to attract students and to obtain funds to jump-start the project.

Source of insights: The insights driving this problem re-framing emerged mostly from the interactions with the communities and key partners including the Pastors. Yet, even before travelling to Bacolod, the students participating in this project gained a few insights that shaped the way they approached the situation on the field. The training process in O-Lab included activities where students designed their own
materials to support interviews, which they prototyped in their local environment with relatives, friends and neighbors. The key caveat in these preparatory tasks was to probe how people perceive and make decisions in topics perceived as personal and that most people would usually not discuss with others. An outcome of this process was that students developed a more sympathetic attitude, and became more open to different ways of perceiving and communicating ideas about sensitive issues.

Degree of change and changes in ownership: The initial “$10 Toilet” framing was compatible with the work of the partners who initiated this project. With ample experience in sanitation problems, it is logical that their framing of the situation would highlight the lack of hygienic conditions to defecate. Such rich experience, particularly WTO’s, also supported the reasoning that the “ultra-poor” condition meant that previous solutions, while inexpensive, were still out of reach for these communities. Hence, the inference of the need to set an even lower benchmark for a solution. The choice to de-emphasize the sanitation problem emerged from inviting the communities to participate in the definition of what made their situation ‘undesirable’. As a result, students noticed that having a clean place to defecate had a lower priority for these communities compared to what was perceived as more pressing problems – or at least, more visible and with more immediate consequences for them. The new problem framing was more compatible with the second partner’s ongoing programs, however it challenged their core mode of operation based on religious membership.

Clarity in new direction and detached commitment: The reframing of this project carried the disadvantage of a loss in brevity and clarity of its mission. Whilst misguided, the initial framing of the problem as a “$10 Toilet” problem was concise, and it prompted ideas in those who first heard about it. However, this is precisely one of the main weaknesses of a problem framing: when people immediately jump to solution mode, they miss the opportunity to reflect on what they are really solving. Technology-driven projects tend to suffer from this flaw, one of the results of conventional engineering education where problems are framed by teachers for students. Motivation levels varied during this project, with three elements sticking out in the process: teamwork, the sense of helping others or “making a dent”, and the field visits which helped students visualize the potential impact of their work.

Complexity, time, and representations: Place-based education remains rather uncommon in education, despite having clear advantages over sessions in classrooms and lecture halls. Immersion in real situations even for a period of days or weeks can transform how students view the problems, their disciplines, and their potential to collaborate with others in complex problem-solving. Preparation is valuable for students to shape their expectations, practice their skills, manage the experiences and interpret the outcomes. Nonetheless, no training is sufficient to fully comprehend new situations that are incommensurable with one’s own upbringing and background, and we witnessed many situations where our students misinterpreted or entirely missed subtle cues during the visits. At other times, the diversity of this small group of students played a key role, as they could exchange views and enrich discussions based on their diverse origins (South Korea, Malaysia, Taiwan, Singapore, and The Philippines). A fundamental ability in this type of projects is that of translation, taken broadly as the skill to creatively re-interpret one worldview or reality into another. One of the main insights driving the re-framing of the “$10 Toilet” project was that beyond income, these communities included a wide variety of individuals and subgroups with very different histories, interests, beliefs, values, and priorities, which repeatedly rendered the “ultra-poor” label rather unproductive as a unifying characteristic.

The work of Opportunity Lab with these groups and across the region of Southeast Asia continues, seeking to understand and enhance the role that design plays in social change. These efforts face several obstacles imposed by archaic ways of defining problems: from the onset, most Universities and gov-
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government officials even in affluent countries fail to provide financial support for students to engage in meaningful learning experiences beyond the classroom and the lecture theatre. A conventional University administrator today is at ease authorizing sizable expenses for laboratory materials and redundant smart teaching technology than for comparatively minor travel expenses to let student experience life in a community. Such learning initiatives must also seek ways to avoid the burden of granting academic credits, and to escape conventional wisdom which would disqualify such projects as “not real engineering”, and “not real architecture” projects. On the other hand, in-place pedagogies do not necessarily guarantee fertile soil for creative problem framing, as evidenced by “Design for Development” and “Design for Developing World” laboratories where the norm is to parachute students and instructors in remote exotic communities. There, they engage in patriarchal roles defining the problems to be solved from their own view of the problem, where technology is invariably the solution (Gerrard & Sosa, 2014). Upon returning to their laboratories and workshops, such experts design and test solutions that function well but ultimately fail to work in a broader sense (Warschauer & Ames, 2010).

GUIDELINES FOR CREATIVE PROBLEM FRAMING IN HIGHER EDUCATION

Based on the experiences described and analyzed in this chapter, the authors suggest the following eight guidelines to promote CPF particularly in higher education:

**Design Across Disciplines:** Studio-based learning (Cennamo et al., 2011) support CPF. In studio projects, students scope problems, define their projects in teams, and develop and test candidate solutions over one or more semesters. These conditions support a variety of learning opportunities and allow for knowledge and skills to be integrated from multiple disciplinary areas, experiences, and cultural backgrounds. Student teams in studio projects do require additional monitoring and coaching on communication, empathy, and time management. Team-teaching by instructors across disciplines provide the best support for CPF in studio projects. However, certain practices hinder studio pedagogies: lecturers that are used to delivering presentations in lecture theatres and applying standardized tests tend to react negatively to any change to their established routine and may be rightfully overwhelmed by the additional time that such changes entail. Studio projects also require changes in the assessment practices, requiring methods that are more holistic than exams and can be indecipherable for people who did not experience studio learning in their own education. Open-ended projects also require high levels of humbleness and flexibility, as a good learning process can take both the students and the instructors to unanticipated areas, themes, and skills beyond those where traditional lecturers feel confident and reinforce their authority.

**Begin Anywhere:** Rather than following a toolkit, instructions, or a method, CPF tends to occur in studio experiences where students respond to a general design brief that resonates with their passion and interests. Student teams can be formed around common areas of interest, but diversity is paramount for creative framings to occur. As in design competitions, the teaching team needs to be flexible to evaluate unexpected re-interpretations of the brief (Rönn, 2009). When the theme “Energy at Home” was given to seventy-five student teams in a first-year undergraduate design course, some teams considered problems where one or both of these concepts were substantially re-interpreted –after all, energy and home are both highly polysemous terms. In traditional art studios, a maximum cohort size of twelve to fifteen students was the norm (Cennamo et al., 2011).
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There are good reasons for such small student-teacher ratios, most of them related to the idea of developing a close relationship between master and apprentice. As studio pedagogies are adopted across disciplines, this is simply unfeasible in most Universities. Creative mechanisms are needed to achieve scalability while avoiding falling back to lecture theaters filled with passive crowds, and standardized tutorials and exams. In our experience, team-teaching, project journals, and online blogging support studio pedagogies in cohorts of around fifty students. Studio projects also require changes in timetabling and curriculum design in order to connect more theoretical or technical learning objectives with hands-on practical experiences. Interim milestones can be scheduled in studio projects, however it is important for instructors to acknowledge that student teams may reach creative framings at different stages of their projects.

Expect the Unexpected: An ethos of expecting unexpected outcomes needs to be instilled and supported in studio projects in order for CPF to emerge. Moreover, this paradox is accentuated by the observation that the unexpected outcome must still “be recognizable as something that is in resonance with what is desired” or specified in the design brief (Nelson & Stolterman, 2010, pp. 48). Assessment rubrics that allow for such seemingly paradoxical outcomes need to be developed by the teaching team. In our experience good rubrics encompass three main dimensions of learning: engagement, outcomes, and reflective practice. Engagement criteria are needed to acknowledge the quantity and quality of work that a team puts on a project, and preferably the individual contributions in the team. Evidence for engagement criteria consists mainly of descriptive records in media such as written reports, oral presentations, or photographs and video. To assess outcomes, one or two deadlines during the semester with clearly defined deliverables serve to build up towards the final project presentation and submission of the final deliverables. Assessments of preliminary materials may be formative, or a ratio of the summative course evaluation. The final deliverables are generally defined by the instructors for all teams, but they may also be adapted with each team depending on their themes, learning objectives, and resources available. Reflective practice is always challenging to develop, teach, and assess. Particularly young students may need clear scaffolding techniques to identify the difference between descriptive and reflective writing. Evidence for this dimension may be collected throughout the project for example by asking students to post well-structured entries in online blogs and preferably to provide feedback to their peers.

Question Everything: Creative studio projects require a permanent tension between skepticism and motivation (detached commitment) that supports learners in developing the capacity to make decisions in conditions of high uncertainty and ambiguity. Instructors of CPF need to develop and practice this same capacity. A series of standard short activities or assignments especially in the early phases of a studio project may be useful to develop and practice this paradoxical ability to make informed choices whilst maintaining an open mind to learning from the journey, interpreting new information, and questioning facts, truths, and established practice. Certain “idea checklist” techniques can be pertinent to structure this practice and to gradually build a culture of developing multiple perspectives, i.e., the Scamper technique (Eberle, 1972).

Diverge and Converge: The “Double-Diamond Model” of the design process can accommodate the structuring of exploratory or divergent and evaluative or convergent decisions. The transition between these phases is often signaled by insights that lead to the reframing of problems. Divergence in CPF refers to both analysis and synthesis activities that expand the problem or the solution space, whilst convergence refers to the opposite type of work, where options are evaluated and only a few are selected. Teamwork is essential to manage these seemingly contradictory processes, supporting the
oscillation of leadership by reinforcing the preferred ways of working of different teammates. The role of instructors in studio projects includes the careful supervision and indirect management of the divergent-convergent balance in a team. Effective instructors identify whether a team is going into convergence too early, or is delaying decision-making by extending divergence for too long, or whether at any point the team needs to switch between these modes either in analysis or synthesis of ideas. Such mentorship requires high levels of confidence and trust to engage in passive observation, take notes and keep track of teams, and to intervene only when appropriate. Instructors intervene in studio projects mainly by posing questions, re-phrasing issues, and guiding students to key concepts and skills aligned with the learning objectives –explicitly avoiding formulaic and standard lessons, or prescribing a particular problem framing or a solution.

Co-Creation: Opening the information and decision processes to active participation by multiple stakeholders of the problem at hand is considered an ethical and constructive CPF strategy. Under this paradigm, creative facilitation is particularly important to help people reveal latent needs, implicit assumptions, and develop dialogue between stakeholders (Sanders & Stappers, 2012). A key co-creation ability is to learn to uncover and listen to feedback, while developing a critical eye to interpret new information and build meaning. Creative formulations are more likely when the opinion of experts and lead users is complemented by listening to those not traditionally considered as specialists. Conventional views of teaching are challenged in effective studio projects, where instructors realize that they can only address a small (but key) number of issues that their students face, as most issues go beyond their own area of expertise. The diversity of the fifteen projects in Table 1 is due to the freedom given to learners in our courses, where they decide for example whether a project that starts as “an app problem” later becomes “a pedagogical problem” or a “human resource problem”.

Brainstorm the Problem: The ideation technique “brainstorming” lists a specific set of instructions, which tend to be overlooked in professional practice, and even in academic studies of creativity (Isaksen & Gaulin, 2005). Appropriate facilitation of a brainstorming session is fundamental, and it is especially important to apply this type of ideation methods to explore alternative problem formulations in addition to their standard use to generate ideas for their solution. Requiring people to prepare beforehand, keeping the session in focus and on schedule, enforcing turn-taking and note-taking, building on the ideas of others, are all important rules for a successful brainstorming exercise. Avoiding criticism in our experience should be extended in CPF to discourage all types of appraisal including commendation, since positive feedback goes against the tentative character of early ideas. Exploring the problem space is necessary but not sufficient in creative re-formulation. Hence, studio projects not only allow for an initial period of problem scoping, subsequent reformulations are welcome as the result of candidate solutions shaping the problem.

A Prototyping Culture: A culture of prototyping and model-making is a core studio feature and essential in CPF, particularly as a way to generate, refine, and develop early ideas. Artistic skills to craft high-quality realistic models are only tackled in the late stages of a project, if at all. For creative reformulations, quick and inexpensive (low-fidelity) physical testing is essential to understand the problem. Under a co-creation paradigm, users and other stakeholders are involved in building and testing early prototypes, and other means of simulation. Rather than testing at the end of the process in order to corroborate initial hypotheses, teams seek from early phases to reveal failures, shortcomings, and inadequate assumptions that inform creative re-formulations of the problem. A
prototyping culture is driven by a learning ethos, hence reflection is an integral phase of testing ideas through prototypes.

These eight guidelines to promote CPF in higher education are aimed at developing the skills, habits, and a culture of questioning what the “problems” are. In a creative culture of problem-framing, sensible problem-solvers are constantly revising their premises, regularly taking measurements anew, and aware of changing conditions, akin a skilled driver negotiating uncertain conditions at high speeds constantly glancing at the rear-view mirror to develop a complete awareness of the situation. Some of these guidelines apply at the individual level, whilst others require teaching teams, and yet a few need structural and organizational changes.

In two decades, the authors have not found an instance of a design, entrepreneurial, or industry innovation project that has not been included in a significant transformation of how the problem was understood along the journey. This does not mean that any re-framing is relevant in the context of creativity. On the contrary, most re-framings during a creative project are in no way more useful or appropriate than the original framing. It can also be the case that a reframing occurs after the problem is solved, upon realization of the consequences of a solution. A classic example is Alexander G. Bell working on improving telegraphy, for which he obtained the US Patent 174,465 in 1876 titled “Improvement in Telegraphy”, the technology behind the telephone. Inventions are indeed a breeding ground for such “post-hoc re-framings”, since teams with the expertise to develop new technology may be uninterested or ignorant of the actual problems that their devices can resolve.

**FUTURE RESEARCH DIRECTIONS**

Each of the ten CPF dimensions presented here suggests a set of research agendas, and in fact they are addressed to some extent in ongoing research efforts. Arguably, the underlying reasoning process behind problem re-framing is related to “abductive logic” proposed by Charles S. Peirce, a mode of reasoning distinct from deductive and inductive inferences, which is highly fallible and unreliable, but is the only logic mode that generates new ideas (Vosniadou & Ortony, 1989). More work needs to be done to better understand how abduction drives creative reasoning (Kolko, 2010). Open research questions related to the framing of creative problems include:

- What pedagogical strategies promote problem re-framing? How may studio projects be scaled, managed, and assessed more meaningfully? (Cennamo et al., 2011)
- How does knowledge representation shape exploration of problem and solution spaces? What mechanisms can problem-solvers apply to switch representations to stimulate creative re-framings? (Goldschmidt & Porter, 2004).
- What drives the generation and processing of insights? What aspects of insight production are transferable? (Klein, 2013).
- How can co-creation support open participation from large and diverse groups, yet avoid ‘regression to the mean’ effects such as ‘design by committee’? (Sanders & Stappers, 2012)
- How can diversity in teams be maximized to promote problem re-framing while allowing adequate communication? (Mannix & Neale, 2005)
- What are the ethical challenges posed by problem re-framing? (Bovens, 2009)
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- What individual traits are suitable for the complementary stages of problem re-framing? (Markman & Baron, 2003).
- What cultural and organizational dimensions determine how situations are considered as undesirable, i.e., how do hierarchies influence problem framing? (Erez & Nouri, 2010)
- What reliable creativity metrics can be developed from problem reframing in addition to conventional approaches based on consensual assessment of outcomes? (Kaufman et al., 2008).

CONCLUSION

The following insight is often attributed to Albert Einstein: “If I had an hour to solve a problem, I would spend 55 minutes thinking about the problem and only 5 minutes thinking about solutions”. This chapter has re-examined the notion of problems and their importance in the context of creativity, and it has presented a collection of instances derived from the authors’ experience supporting problem reframing in design innovation projects. In order to support the development of Creative Problem Framing (CPF) skills in University programs, the authors suggest to adapt studio-based experiences across disciplines to enable students to experience CPF in practical, meaningful, and fun ways. In such experiences, creative problem-solvers learn to approach situations in radically different ways and they develop an understanding that their creative efforts start, and are fundamentally determined, by framing problems.

CPF has been presented in this chapter as an explicit process of un-taming situations in order to bring their wickedness out. Key dimensions have been discussed in this chapter, including the importance of how problems are initially presented, where and how insights about a problem originate, the extent to which a problem is transformed, the clarity provided by new framings, the ways in which ownership affects and is affected by the re-framing, how knowledge is represented, the tension between perseverance and openness, and the importance of learning. Lastly, guidelines are discussed to design studio experiences in higher education where CPF can emerge, and future research directions are presented.

REFERENCES


**KEY TERMS AND DEFINITIONS**

**Abductive Reasoning:** A mode of thinking that is different from deductive and inductive inferences, also known as “the logic of informed guesses”; considered the reasoning mode that introduces new ideas, hence it is called “the logic of creativity”.

**Creative Problems:** Or Creative Problem Framing, a definition or formulation of a problem statement that redefines the solution space, allowing for novel and valuable solutions.

**Design Brief:** The (usually) written set of requirements, goals, and information used to initiate a design project, usually authored by a client or in partnership with a client. It serves as a type of agreement that sets the direction for problem-solving in a design project.

**Divergent Reasoning:** A mode of thinking that seeks to expand the set of possible and relevant answers or solutions to a problem. Its counterpart is convergent reasoning, where the goal is to reduce the space of solutions by applying evaluation and selection criteria to a pool of alternatives.

**Generative Design Methods:** A family of design methods, activities, and techniques aimed at idea generation, usually aimed at facilitating participation from a wide range of stakeholders.

**Intrapreneurship:** Entrepreneurial activities of individuals employed by large organizations or corporations.

**Problem Space:** A representation of the initial and goal states of a problem.

**Problem-Solution Co-Evolution:** The mutual process of change between the problem and the solution spaces, that is, the problem definition and the range of solutions available given such definition.

**Prototyping:** The iterative process of testing and modifying new ideas usually by means of physical or virtual embodiment.

**Solution Space:** A representation of the set of all feasible solutions that satisfies a particular problem framing.

**Studio-Based Learning:** A pedagogical strategy derived from Fine Arts (Beaux Arts) education where a small group of apprentices learn under close tutelage of a skilled master.

**Wicked Problems:** A type of problem definition that defies complete resolution and where requirements are not fully articulated and change over time. Truth or correctness of solutions to wicked problems cannot be established, therefore no ultimate test exists.

**ENDNOTES**

3. “The brief is broad. We’re looking for designers who think differently to create products that work better. Engineers who follow an iterative design process. Rough and ready prototypes. Products that have a significant and practical purpose, are commercially viable, and are designed with sustainability in mind.” [http://www.jamesdysonaward.org/the-brief/](http://www.jamesdysonaward.org/the-brief/)
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4 World Toilet Organization, Singapore: http://worldtoilet.org/
5 ICM training programs: http://www.caremin.com/our-work/transform
6 Opportunity Lab, O-Lab website: http://www.opportunity-lab.org/
Chapter 22

On the Relationships between Creative Learning, Creative Teaching, and Roles of Creative Teachers

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ABSTRACT

This chapter aimed to discuss the relationships between creative teaching, creative learning and the role played by creative teachers in the contexts of students’ creativity development. Firstly, this chapter analyzed the characteristics of creative teaching and creative learning. The history of the research on creative teaching and learning since the first half of 20th century was briefly introduced. Secondly, the authors discussed the nature of creative teaching, the features of creative teachers compared to non-creative teachers, the environment for the development of creative teachers and the measures that should be taken to promote the growth of creative teachers. Accordingly, this chapter contributes to development of creativity in higher education both theoretically and practically in the future.

INTRODUCTION

It is well known that the creativity development has been paid great attention since human beings entered the 21st century. Most countries put particular emphasis on creative teaching in higher education in order to promote the learner’s creativity and the growth of creative talents. However, it has been controversial for the nature of the creative teaching, creative teaching methods, and the growth of creative teachers, despite many studies have been done on such topics.

The objective of the chapter is to clarify the relationships between creative teaching, creative learning and creative teachers, and to point out the way to creative teaching based on the discussion of the role of creative teachers in the contexts of students’ creativity development. In the following sections, the brief review of the history of studying creative learning and creative teaching will be firstly conducted,
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and the characteristics of creative teaching and creative learning will be analyzed. And then the features of creative teachers that are necessary for developing creative teaching will be discussed. Finally, this chapter will focus on how to foster the growth of creative teachers.

BACKGROUND

Undoubtedly, creativity has been the key theme of 21st century. According to International Society of Technology Education’s National Educational Technology Standards for Students, the first educational technology standard for students is “creativity and innovation”. Similarly, the standards set by American Association of School Librarian (AASL) for 21st century learners emphasized that learners create new knowledge, express their innovative opinions, and create new and useful products in realistic life (Johnson & Lamb, 2010). Accordingly, in the era with creativity highly emphasized, creative teaching has been developed rapidly and constituted the core of creative education, which represents the current trend of education in diverse countries around the world.

Due to the influences of progressivism that was prevalent in the first half of 20th century, as a headmaster of Wisconsin Middle School, H. L. Miller in Department of Education, University of Wisconsin in the U.S.A, published the book Creative Learning and Teaching, based on his educational practice, in 1927. In this book, Miller claimed that every student had enormous potentials for creativity development, and teachers should not set the upmost limit for the students. According to Miller (1927), learning should be the process in which students actualized themselves and found their potentials, and in the process students developed themselves, regulated themselves, improved themselves, changed themselves, tested themselves, and created themselves, and they are not “custom-made” by teachers. Accordingly, teaching was not the process in which schools provided some kind of “articles of order” or “parts” for society, and teachers solely provided some sort of knowledge or conclusion, but the process in which they should liberate students, inspire creativity, and guide students to find the novel solutions. Therefore, Miller (1927) suggested creative learning should be regarded as a result of creative teaching from a perspective of how to teach. Obviously, Miller’s ideas reflected the theory of progressivism that emphasized to develop children's ability as the core of teaching process. Actually, at that time, the school education in the U.S.A was deeply affected by the progressivism that improved greatly contemporary classroom atmosphere and democratized the relationship between teachers and students that still can be found today.

Influenced by Jean Piaget’s theory of structuralism, a famous educator and cognitive psychologist, Jerome Seymour Bruner (1960) put forward a series of concepts: knowledge structure, analytic thinking, intuitive thinking, spiral course, discovery learning, and heuristic method. These concepts elaborated the development his structuralism theory of education that has been shown in the published book The Process of Education in 1960. As emphasized by Bruner (1960), students should be guided to learn to study by heuristic teaching, which inspired a series of relevant scholastic exploration. For example, in 1967 B. G. Massialas and J. Zevin discussed how to improve the ability of analytic thinking and discovery learning in the courses of the disciplines such as biology, geography, language, music, and society, etc. They stated that students’ motivation for exploration should be inspired, and teachers should encourage students to draw their own conclusions based on the materials provided and to discover the relationships between diverse concepts in the processes of achieving the conclusions.

In the 1970s, researchers began to explore the learning process from a perspective of creative thinking due to the influences of cognitive studies development. For example, E. P. Torrance and R. E. Myers did
significant contributions to this aspect. Ellis Paul Torrance at University of Georgia and R. E. Myers at University of Victoria in Canada published a book *Creative Learning and Teaching* in 1970. They discussed the meaning of the two concepts: creative learning and creative teaching. Meanwhile, they suggested the two phenomena happened hand in hand. According to Torrance and Myers (1970), in the process of creative learning, the learners would be sensitively aware of some factors such as a sort of problem or limit, deficiencies of knowledge, and discontinuities or gaps between different knowledge areas; they would collect and synthesize all kinds of information; they would clarify what the difficulties or deficiencies are; they would try to find the solutions to the problem, or guess and propose the hypothesis; they would test and re-test the hypothesis and modify it until they finally found the solution as the conclusion. The basic phases constituted the process of creative learning through which learners obtained the information that was novel and original for themselves, or acquired new skills. The creative motivation involved itself in each phase. In other words, the motivation for creation, cognition for creation, and creative behavior blend together in the process of creative learning. When creative learning happens, a learner is willing to put all his or her heart into the activity which is valued by him or her; when faced with the puzzle, challenge, imperfection, disharmony, and confusion, a learner is anxious to know about the truth and solve the problem; a learner will synthesize and assemble the knowledge he or she owns already, and form the new knowledge, or make sure what the current discontinuity or difficulty is; a learner will produce many solutions or hypotheses to make the process of problem solving to be more thorough and definite; a learner will judge, evaluate, check, and test the hypotheses; a learner will give up those unsuccessful, erroneous, or inapplicable solutions and hypotheses; a learner will select the optimal solution and make it attractive and aesthetic; and finally a learner will transmit or disseminate the result to others (Torrance & Myers, 1970).

Therefore, creative teaching aims to provide the environment for students to improve their creativity. In the process of creative teaching, teachers are often highly responsive to their students. Especially, they can recognize the needs of students and give the necessary instruction; they listen to students’ ideas and care about what they think and feel; they respect students’ opinions and respond to them; they approve of students’ hard-working behavior; they will not speak to students ironically. Torrance and Myers (1970) summarized that the creative teaching should permit students to study according to their own styles; the teachers should adjust the process of courses according to students’ needs, and prevent students from being punished physically or mentally. In one word, teachers should provide the non-punitive environment in which the student can be accepted and tolerated that may change and the negative opinions on creative behaviors of a group, a class, or even a school.

Based on the relevant research, Torrance and Myers (1970) pointed out that it was possible to teach creatively that can achieve the visible effects. Through creative teaching, students can learn to think and solve problem creatively. Although some people, including some teachers, still think that students’ creativity cannot be improved by teaching, there are more evidences supporting that creative teaching can elicit the positive changes in many aspects: the improvement of reading ability, verbal ability, and academic performance; the decrease of violative behaviors such as fighting or hostile behavior and the increase of constructive behavior; the increase of social acceptance; the increase of the passion for learning and schooling; the increase of self-esteem and creative expression; the improvement of attention; and the decrease of mental disorder.

The systematic statement about creative behavior emerged in the 1970s. J. W. Botkin, M. Elmandjra, and M. Malitza (1979) put forward the concept of innovative learning suggesting a similar meaning with creative learning. According to them, learning is the process in which learners acquire the knowledge,
live and tap their potentials of creativity, and make preparations for coping with new environment. It is different from the concept of maintenance learning, innovative learning is a sort of learning by which the learners elicit the change, renewal, reorganization, and a series of new questions. Compared with innovative learning, maintenance learning can help students acquire stable value of the world, methods, and rules to cope with the situations where repeatedly emerge and learners are familiar with. It can improve our ability of solving the routine problems, and help us maintain the exist living styles. So it is indispensable to maintain social stability. However, innovative learning is necessary in order to adapt to all sorts of new environments.

According to Elmandjra and Malitza (1979), anticipation and participation are two features of innovative learning. In the innovative learning, humans can anticipate the possible events and conflicts, and the measures or coping strategies that they can take. By anticipatory learning, we can choose those events or situations that are favorable to us, and further take helpful measures, to avoid the possible disaster. Meanwhile, innovative learning calls for a broad scope of subjects' participation arranging levels from individuals, groups, organizations, regions, to nations. Compared with maintenance learning aiming to solve the problem with clear goals, innovative learning is the process in which learners find, define and classify the problems, by which learners can question or criticize the conventional thinking and opinions in order to bring about new and necessary changes.

Since the 1980s, the concept of creative teaching has been used widely, and a series of books about creative teaching have been published which systematically analyzed the patterns and methods of creative teaching. These books included Encouraging Creative Learning for the Gifted and Talented: A Handbook of Methods and Techniques (Treffinger, 1980), Early Childhood Education: Creative Learning Activities (Barbara, 1983), Creative Problem Solving: The Basic Course (Isaksen & Treffinger, 1985), and The Handbook of Creative Learning Exercises (Engel, 1994). Besides these books, the researchers have put forward a series of new theories. For example, Treffinger et al. (1983) summarized the research on creative thinking in the process of creative teaching, and put forward the three-level model of creative teaching which was characterized by three levels: 1) divergent thinking, 2) synthesis of thinking and affection, and 3) creative activities for meeting the real challenge. Notably, both creative teaching and creative learning were mentioned at the same time generally.

Since the 1980s, Chinese researchers such as Chongde Lin (1999, 2000) began to explore creative teaching and learning. In recent years, the Chinese researchers have studied diverse learning styles such as “exploratory learning” and “automatic learning”. However, little attention has been paid to the concept of “creative learning”. But a distinction between repetitive learning and innovative learning has been made. According to Lin (1999, 2000), repetitive learning is centered on textbooks and teachers, and accordingly students only follow what they are told. On the contrary, automatic exploration and creation are valued in the process of innovative learning in which students present their initiative learning strategy, learning motivation, and learning objective, and they can not only acquire the knowledge from their teachers, but also “find” new knowledge by themselves. So students are willing to reflect and regulate their learning process in order to learn better.

In conclusion, although the research on creative teaching and creative learning has a history of almost 100 years, it still has a long way to go. With the development of society, the new media technology such as the Internet will challenge the models of creative teaching and learning. The new era will also provide new opportunities to the research of creative teaching and creative learning in the future.
The Features of Creative Teaching

Creative learning depends on creative teaching to a large extent. In other words, creative teaching is a condition of developing creative learning. Despite there are different opinions on the procedure and method of creative teaching in the literature, some features of creative teaching have been recognized that will be discussed in the following:

Firstly, teachers encourage students’ free exploration, and students have enough freedom to ask questions and discuss with others, to choose their own learning styles, to explore and study independently, and to learn by group. Students can choose the appropriate learning method to meet their own needs.

Secondly, teachers do not stress the punishment for students, but provide the open atmosphere for students. Teachers respect and accept each student for their individual differences, and recognize the individual potential. They do not simply judge each student’s answer as right or wrong. Ewing and Tuthill (2012) proposed that teachers should escape from excessive rewards, highly structured teaching materials, and the unique right answer. The teacher should permit children to express their own ideas even through the ideas were odd, because children are more willing to put forward new ideas when they are encouraged to take risks than the adults. It is also very significant for teachers to express their passion for children’s exploration. When learners have the psychological freedom and enough sense of security, they will not worry about their behavior that will be criticized or satirized and they will explore what they are interested in accordingly.

Thirdly, in the process of creative teaching, teachers should provide specific scenario of real-life problems to inspire students’ passion for creative learning process. They should put emphasis on the facilitation of students rather than on instilling knowledge into students’ mind, on illumination rather than on preaching, on the participation in students’ activities rather than ordering students toughly, and on students’ independence rather than their reliance and dependence. In other words, teachers play the roles as an inspirer, a guide, a participant, and a helper. They can adjust teaching content and methods flexibly according to individual differences of students. For example, in a study, the researchers (Jiang, Zhou, Chen, Bin, Qin, Cen, et al., 2012) turned the learning of monotonous pharmacology knowledge into sitcoms and second-classroom, which improved greatly students’ interests and creative thinking abilities, and enhanced their interpersonal abilities and cooperative abilities. In another study, drama was used as the method in supporting the development of students’ creativity (Toivanen & Halkilahti, 2014). Sternberg (1991) put forward Investment Theory of Creativity which stressed individual creativity is the synthesis of individual intelligence, knowledge, thinking styles, personality, and motivation within a specific environment. In the process of creative teaching, teachers instruct students to invest creative thinking styles, knowledge available, intelligence, and motivation and personality for creation and production of creative ideas and creative behaviors (Gu, 2005; Gu, Zhou, & Fan, 2010).

Based on the relevant research, Chen (1999) suggested that the teaching style aiming to improve students’ creativity could provide democratic atmosphere, permit students to have their own ideas, and postpone the judgment; it also encourages the open question which has not unique answer; it could permit students to study independently and did not attack students for their failure or error; it could encourage students to lay the foundation of knowledge; it could improve the method of evaluation of students. Kwang (2005) pointed out that creative teachers tended to support students’ autonomy, and to provide students with the opportunities to present their creativity. Yaolin, Zou, Zeng, Sun, and Wang (2014) adopted the qualitative methods to interview 17 students and 28 teachers who experienced the program of creativity development. It was found that creative classroom had the following features such as encouraging
and supporting, permitting autonomy, guiding exploration, and ignoring and suppressing. This study indicated that creative classroom had positive effects on students’ openness and daily creative behaviors.

Creative teaching emphasizes that students apply what they have learned to the practice in the context of solving problems. Yaqoob (2012) adopted the Cognitive Teaching Model (CTM) in the literature studies of postgraduates aiming to improve students’ cognitive abilities and creative thinking techniques. The model included four phases: 1) reviewing the text, 2) shaping interpretations, 3) making connections, and 4) extension. The purpose of the phase of ‘making connections’ and ‘extension’ was to encourage students to apply “old” knowledge to the understanding of “new” knowledge. Yaqoob (2012) highlighted the results of applying this model were significant to develop creativity.

Creative teaching is a kind of learner-directed teaching. In the process of creative teaching, the teacher should firstly inspire learners’ interests in learning material, and then lead students to find the problem by themselves, or the teacher should present specific problems and ask learners to apply all sorts of available resources to find the best satisfying solution (Gu, Zhou, & Fan, 2010). In a study with teachers and school leaders from 11 elementary and middle schools in mathematics education, Lev-Zamir and Leikin (2011) found that learner-directed teaching helped to improve the students’ flexibility, fluency, and originality of thinking. However, teachers’ flexibility, originality, and sensitivity were also needed to develop creative teaching, since teachers’ creativity was necessary for students’ creativity, and the interaction between creative teachers and students could elicit students’ creativity in mathematics education.

In conclusion, creative teaching helps to bring about creative learning. Meanwhile, creative learning affects creative teaching conversely. They are inseparably interconnected and affect each other.

THE FEATURES OF CREATIVE TEACHERS

What are the general features do creative teachers have? In fact, creative teachers are those who promote creative learning by methods of creative teaching. Although they are somewhat different in teaching styles and specific teaching behaviors, they have some common features that will be illustrated in the following sections.

Educational Notions of Creative Teachers

Generally speaking, creative teachers emphasize the pedagogical methods of acquiring knowledge instead of preaching; emphasize the respects between the teachers and students; emphasize the learning practice inside as well as outside classrooms. In the eyes of creative teachers, each student is different from each other. Teachers should provide students with individualized education. Each student has his (her) specific potential that should be tapped in different ways.

In other words, creative teachers know how to develop students’ creativity. Specifically, they understand to develop creativity as one of teaching goals in answering the following questions: 1) what sort of knowledge do they want to transmit to their students? 2) What values do they want to cultivate? 3) What expectations do they hold for students? And 4) what responses do they want to see from students?

Besides those questions, they have clear teaching content and flexible methods in response to: 1) what materials that they can use to achieve the teaching goal, 2) what sort of method that should be adopted, and 3) how to evaluate the learning result. All the above points are necessary for creative teachers to conduct their teaching creatively.
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Some researchers such as Fryer (1996), Diakidoy and Kanari (1999), Cheung, Tse, and Tsang (2003) found that, in the eyes of creative teachers, what was most important for students is to enhance their autonomy and self-confidence. Students should have the chances to choose the task or regulate learning by themselves; students should be encouraged to ask questions or think about the open-ended questions creatively. Actually, just as what Joubert (2007) reported, when teachers act out the educational notions in the real teaching contexts, they do not feel at ease because students often challenge their teachers, or disobey what teachers said and present out of the ordinary. Therefore, creative teachers need the courage to meet the possible challenges from their students.

Furthermore, creative teachers have rational and enormous knowledge, including sufficient knowledge about educational method and techniques. They know what to teach and how to teach, and they are familiar with the profession or course that is being taught. Furthermore, they know about the way in which creativity can be inspired, and provide the atmosphere for students to learn creatively.

Features of Personality and Specific Behavior of Creative Teachers

As a kind of creative talent, creative teachers present their creative personality and behavior in education. Despite there are the differences in different teaching situations, creative teachers tend to have some principal features that were presented in practice of creative teaching.

Personality Traits of Creative Teachers

Openness
The creative teachers tend to be open to novel experiences, which means that they are highly sensitive and tolerant to something new especially, and that they have strong desires for new knowledge and exploration. Openness is the common personality that creative talents have, and creative teachers are no exception. They have no superstitious belief about extant teaching mode and authorities, and can find the appropriate and novel teaching styles by thinking independently. They tend to be curious about new notions, new ways, and new methods, which makes their teaching unlimited to one style. Creative teachers should listen to different opinions and be open to students, and treat others’ criticisms calmly (Fautley & Savage, 2007; Sanchez, Martinez, & Garcia, 2003). Lee and Kemple (2014) found that those teachers with high level of openness tended to participate in more creative activities, and were more likely to teach creatively and encourage students’ creative behavior.

Independence
The independence of creative teachers means that they do not follow the established rules or practice, and choose appropriate teaching ways independently. They tended to have their own ideas about any specific problem and find the solution according to their own understanding. They often question and challenge the authority. They also permit and encourage students to express themselves independently and respect their ideas and desires for exploration.
Motivation of Challenging Complexity

Motivation of challenging complexity means that creative teachers tend to strive to find the logical solution to a difficult or complex problem. They will overcome the difficulties and have the courage to face and solve the problems. Tanggaard (2011) found that creative teachers were willing to examine the effect of new teaching method among students despite the possible difficulties. Actually, individualized teaching itself designed for each student’s features is a complex task for teachers.

Passion for Creative Education

Creative teachers are often filled with passion for creative education and love with students. This ensures their investment into their teaching work. Whitlock and DuCette (1989) concluded that creative teachers tended to have passion and empathy for students, and to dedicate themselves to the teaching work, which was very significant for the development of students’ creativity. McGreevy (1990) asked student participants to list the features which their most liked creative teachers have, and found that, in the eyes of students, these teachers tended to be humorous and open to accept students, and to listen to students’ ideas; furthermore, they expressed themselves naturally in the classrooms, and understood and care for each student, especially those with poor academic performance. Woods (1995) and Jeffrey and Craft (2006) concluded that creative teachers liked innovations very much; they cared for the development of each student, and hoped to find the way in which the specific need of each student was met; they concentrated on teaching and love their students deeply. The passion for teaching drives them to put all their hearts into their work.

Features of Creative Teachers’ Behavior

The explicit behaviors of creative teachers in the classroom are outward manifestation of their personality. They allow the students enough freedom to explore and study creatively.

Respect and Tolerance for Students

Creative teachers show enough respect and tolerance for their students. Respect means that teachers treat students impartially, and protect their dignity. In the eyes of creative teachers, teachers should not be the persons of absolute authority. On the contrary, teachers should treat each student as the person just like themselves. Specifically, creative teachers respect students’ rights, interests, independence, and autonomy, and give students enough freedom to make decisions rather than impose their ideas on students or substitute their judgment for students’ judgment. Each student is a special person with specific interest, will, and ideas, and teachers should understand him or her, and guide him or her to develop creativity in the right way.

Generally speaking, the respect of creative teachers can elicit the atmosphere that provides enough psychological freedom and sense of security for students to think and practice courageously, which actually lays foundations for creative exploration. The atmosphere contributes to the development of complexity, curiosity, imagination, and risk-taking.

The tolerance for students means that teachers permit their students to make mistakes in the process of exploration, and give them enough time and room for exploration. When students solve the problem creatively, or think in a flexible, original, novel, and fluent way, they probably disobey their teachers,
or refuse to follow the rule that teachers hope them to follow, which may result in the conflict between teachers and students. In fact, many teachers like those students with good academic performance more than those with creative behavior. Therefore, creative teachers should prevent themselves from evaluating students negatively. In other words, they should value any creative behavior or any desire for creation of students.

**Support and Encouragement for Students**

Creative teachers tend to support creative learning of students, and provide the supportive environment for them. They encourage students to become automatic learners. It is evidenced that automatic learners have great interest in learning process itself, and they have knowledge-directed goals instead of performance-directed goals (Kwang, 2005). Because of the support and encouragement from teachers, the students have strong self-efficacy and more creative behaviors.

In the process of creative teaching, creative teachers encourage students to put forward as many solutions to the problem as possible, and strive to inspire students’ interests in innovative learning (Jeffrey & Craft, 2006). They also put emphasis on students’ acceptance of those ideas different from theirs (Craft, 2008).

Frederiksen (1984) concluded that, creative teachers gave students enough time for thinking, postponed the judgment of their answers; they encouraged students to do something being interested and permit students to have fun or playfulness; they encouraged students’ originality of ideas those are different from others; they taught students how to think and solve problems creatively; and they gave positive feedbacks to students. This will enhance students’ sense of security and motivation for creative learning. Fautley and Savage (2007), Sanchez, Martinez, and Garcia (2003) also pointed out that, creative teachers tended to encourage the learners to take some rational risks and answer the open-ended questions, and to encourage them to positively participate in all sorts of creative activities; they enhanced the self-confidence and self-regulation, and encouraged them to think from a different perspective and find the novel solution of problems.

**The Ability to Construct the Harmonious Relationship between Teachers and Students**

Creative teachers stressed that harmonious relationship between teachers and students contributed to creative learning of students. Researchers such as Sanchez, Martinez, and Garcia (2003), and Fautley and Savage (2007) concluded that creative teachers had close relationship with their students and brought their initiatives into creative learning. These teachers were also equipped with sufficient educational and psychological knowledge and knew how to promote the creative learning of students.

Firstly, they are familiar with the regularity of education and apply it to their teaching conscientiously. In the teaching contexts, they love students and like to interact with them inside and outside the classroom. They know about the needs of students and design their teaching according to the specific needs. Therefore, the student is willing to make friends with their teachers and to get along with them equally.

Secondly, they usually have sufficient teaching experiences and know how to teach in the classroom equally, harmoniously, interactively, and effectively. This also helps students to learn creatively and arouses them to solve the problem in a novel way. Just as mentioned above, a creative teacher tends to encourage and praise students’ originality, which elicit some sorts of satisfaction of the student. The positive interaction of teachers with students can consolidate the harmonious relationship between teachers
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and students and enhance the motivation of creative learning among students. The teaching behavior is also been intensified in the process. In sum, creative teaching benefits both teachers and students.

Putting Emphasis on Intrinsic Motivation of Students

Amabile (1983, 1996) put forward the intrinsic motivation hypothesis emphasizing intrinsic motivation can enhance one’s creativity; however, extrinsic motivation can reduce one’s creativity. Mass research on artistic and language creativity has supported this hypothesis. In fact, intrinsic motivation or great interest will drive the learner to devote himself to learning creatively and overcoming the difficulty in solving all sorts of complex problems. The creative learning driven by the intrinsic motivation or interest is usually more effective.

Creative teachers tend to adopt the student-centered activity and link what to learn with the reality to bring students’ initiatives into learning. They are also adept in raising the question with open ends to inspire divergent thinking of students. Besides that, they may use modern technology (e.g., multimedia) to present what to teach and enhance students’ interests in learning. In the teaching process, they are able to reinforce the learning results and the learning processes of students and praise them with their efforts, which may contribute to intensifying students’ intrinsic motivation of creative learning.

Actually, the appropriate classroom atmosphere stimulates the intrinsic motivation. Mao (1999) concluded that, creative teaching depended on the following conditions to a large extent: 1) democratic teaching atmosphere to ensure students to have courage to express themselves without criticisms or sarcasms, 2) teachers’ willingness to listen for students’ ideas, postponing the judgment of students’ ideas, 3) open-ended questions which inspire students’ imagination and learning motivation, 4) encouragement for independent exploration of those students with special talents, and 5) permitting students to make mistakes. The comfortable classroom atmosphere contributes to thinking divergently and producing many kinds of solutions of the problem. Khatena (2003) also found that if teachers understand and respect children, this helped to develop special talents such as creativity. For teachers, the cooperation between teachers and administrators is indispensable for creative teaching that is helpful to stimulating intrinsic motivation of creative learning (Bramwell, Reilly, Lilly, Kronish, & Chennabathni, 2011).

FOSTERING THE GROWTH OF CREATIVE TEACHERS

Just as the development of students’ creativity, the creativity of teachers requires to be developed gradually under specific conditions. Specifically, if a teacher wants to be creative in teaching, he or she should be equipped with creative personal characteristics and necessary abilities, notions and knowledge. Meanwhile, the authorities or administrators should provide the opportunity or environment that helps to develop teachers’ creativity.

Equipping Teachers with Scientific Notions about Creative Education

Just as mentioned above, creative teachers tend to have scientific notions about education. It means that a teacher should be equipped with scientific notions about creative education.

Firstly, teachers should be clear about the roles they should play in creative education. Kwang (2005) summarized the roles creative teachers played in the classroom: dedicated coach, experienced guide,
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catalyzer of intelligence, smart judge, and illuminative scholar. As a dedicated coach, the teacher should love his or her educational work, provide students with sufficient time and resources for their problem solving, and permit students to make mistakes. As an experienced guide, the teacher should be adept in guiding students to achieve specific goal by automatic exploration, and be adept in inspiring their interest in the question. As a catalyst of intelligence, the teacher should be good at catalyzing students’ thinking, and encouraging them to study in a creative way. As an illuminative scholar, the teacher should provide support for the creative learning of students and ensure them to have sufficient freedom and sense of security, and make them feel that they are mans of free will. As a smart judge, the teacher should encourage students to solve problems by themselves and express their ideas, and judge students’ ideas appropriately and equally. If a teacher can play the above roles well, students will feel that they have freedom to make decisions, and feel safe while taking risks or making mistakes, and they are willing to meet all sorts of challenges in learning activities.

Secondly, teachers should have the scientific notions about the nature of creativity, the factors of creativity, and the method of creativity development. In other words, they should have appropriate opinions on the following questions: “What is creativity?”, What roles will personal characteristics and environmental variables play on creativity development?”, “How can we be creative?”, and “How can we educate a person to make him or her more creative?”. Actually, creative teachers realize that each student has great potential for creativity, and they understand the nature of creativity and support the exploration and creative learning of students. Creative teaching should be student-centered, encourage creative learning and questioning of students, respect individual difference of students, and pay attention to practice (Yu, 1996).

In recent years, many teachers have laid more emphasis on examination scores in developing countries such as China, and the students have to exert great efforts to cope with frequent examinations of many subjects, which damaged greatly students’ interests in creative activities. Students have no time and room for the activities outside the classroom. Accordingly, the teachers spent a great amount of time preparing for the delivery of knowledge from textbooks and asked students to get the best scores. In this context, in the eyes of the teachers, good students are not those who are creative but those who score best. Creativity is not as important as scores because it is not necessary for the entrance into the colleges or universities. So as the creative teachers, they should realize the significance of creativity for students’ development and societal development, and should be equipped with the notions about creative education.

Specifically, creative teachers ought to have the appropriate notions of the subject of creation, the process of creation, and the evaluation for students’ development. They should realize that each student have the potential of creativity and produce creative ideas; both personal characteristics and the environment play the important role on creativity development; excellent students should be those who are creative in and outside the classroom. The notions held by teachers will have direct impact on their teaching behaviors which will further affect students’ creative learning.

Equipping Teachers with the Ability for Creative Education

Undoubtedly, creative teachers should be able to design their teaching in classroom, put forward the appropriate scenario that can inspire the creativity of students, and solve the problem emerging in the process of teaching, and finally achieve the anticipated goal of teaching.

How should teachers create the atmosphere that contributes to creative learning? Chen (1999) concluded that, despite there are different opinions on this question, most scholars agree on the following:
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1) Take each student seriously, and value freedom, security, democracy, cooperation, and respect in the classroom; 2) Encourage each student to learn to express himself or herself and explore confidently; 3) Provide students with the open-ended question and inspire their interest and divergent thinking; 4) Value all ideas of students, and encourage the ideas different from others; 5) Encourage all students to participate in the activity in and outside the classroom, and teach them in accordance with their aptitude; 6) Prevent students from having blind faith in teachers; 7) Permit students to fail or make mistakes in the process of learning, and encourage them to learn from failure; 8) Encourage students to study independently and participate in the learning activity outside the classroom; and 9) Defer the judgment over students’ opinions. Therefore, it is more probable that a teacher becomes creative in teaching if he or she is equipped more with these abilities.

Therefore, a creative teacher should be familiar with the method of instruction for creativity in order to achieve this goal. There is enough evidence that supports the effect of discovery learning on creative thinking of students. In the 1960s, the educational psychologist Jerome Seymour Bruner firstly put forward the term “discovery learning”. In the context of problem-solving, discovery learning means that the learner draws on his own experience and prior knowledge and interacts with the learning environment by exploring and manipulating objects, wrestling with questions and controversies, or performing experiments. Finally, the learner is expected to discover the truth behind the phenomenon to some extent.

However, there are some debates in the literature concerning the efficacy of discovery learning (Mayer, 2004). Discovery learning may be highly complex and generates a heavy working memory load that is detrimental to learning. In order to overcome the shortcomings, enhanced discovery learning was put forward, and as a process, it involves preparing the learner for the discovery learning task by providing the necessary knowledge needed to successfully complete the task. By this approach, the teacher not only provides the necessary knowledge to complete the task, but also provides necessary assistance. The enhanced discovery learning also allows the learner to generate ideas about a topic along the way and then having students explain their thinking. A teacher who asks the students to generate their own strategy for solving a problem may provide with examples in how to solve similar problems ahead of the task provided in discovery learning (Marzano, 2011).

It is clear that this method of instruction is beneficial to the development of critical thinking and creative thinking. In fact, the label of discovery learning can cover a variety of instructional techniques. It is most important for teachers to promote the automatic exploration of students by encouraging them to study independently or cooperatively. A creative teacher should know about it and apply it flexibly.

Mastering the Creative Techniques

Creative techniques are those ways or procedures that elicit the creative thinking of individuals or groups. In recent years, researchers have found out many creative techniques among which some can be applied to creative teaching (Zhang & Gu, 2005). As a creative teacher, he or she should master some creative techniques so as to better train students’ creative thinking.

One of most famous creative techniques is brainstorming. It is a group creativity technique by which a list of ideas spontaneously contributed by its members is gathered to find the best solution to a specific problem. In 1953, Alex Faickney Osborn firstly popularized the term in the book Applied Imagination. According to Osborn, brainstorming was more effective than individuals working alone in generating ideas, although more recent research has questioned this claim (Diehl & Stroebe, 1991).
There are two principles that contribute to “ideative efficacy”: defer judgment, reach for quantity (Osborn, 1963). Following the two principles, four general rules of brainstorming were established with intention to reduce social inhibitions among group members, stimulate idea generation, and increase overall creativity of the group:

**Focus on Quantity**

This rule aims to facilitate divergent thinking in problem solving through the maximum quantity breeds quality, with the assumption that the greater the number of ideas generated, the greater the chance of producing a radical and effective solution.

**Withhold Criticism**

Criticism of ideas generated should be withheld. Instead, participants are encourage to extend or add to ideas, reserving criticism for a later “critical stage” of the process.

**Welcome Unusual Ideas**

Unusual ideas are welcomed, and are generated by looking from new perspectives and suspending assumptions.

**Combine and Improve Ideas**

Good ideas may be combined to form a single better good idea. It is believed to stimulate the building of ideas by a process of association.

Actually, brainstorming provides a sort of atmosphere where encourages the idea generation. By suspending judgment, participants will feel free to generate unusual ideas. In the process of teaching, teachers can adopt the techniques to enhance creative thinking of students. It is most significant for teachers to create the encouraging and supportive atmosphere and to instruct students to know how to think about the solutions to a problem.

**Providing Teachers with the Supportive Environment**

The growth of creative teachers needs the supportive environment in the institutions. So the educational administrators should take necessary measures to encourage the development of teachers’ creativity in teaching, especially by making the encouraging policy and creating the supportive atmosphere, which has a direct effect on their motivations for creative teaching.

It is important for the administrator to realize that the creative teaching is directly affected by the evaluation systems. West et al. (West, Williams, & Williams, 2013) found that the effective evaluation within a group greatly improved creative problem solving of the group. They thought that this result could be applied to colleges and higher education. It is necessary for schools and local educational authorities to provide an environment in which teachers feel free and secure. Firstly, they had better form the evaluation system of instruction that encourages teachers to pursue the success of creative teaching. Teachers ought to have enough time and resources to test their new programs of instruction. In fact, in
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some Asian countries such as China, the teachers have to face with the conflict between creative instruction and the requirement of examination scores. On one hand, they have the strong desire for creative teaching and the promotion of creativity of students; on the other hand, they are required to ensure the student to meet the standard of obtaining the high scores. In a study of Tanggaard (2011), she pointed out such conflict is possible to bring negative effect to creative education. This is due to much emphasis has been put on the scores that mainly helps students to learn how to cope with the examinations, and there is not much time for teacher to spent on creative instruction.

So it is significant for educational institutions to provide effective training program to teachers. Just as mentioned above, creative teachers tend to be equipped with necessary notions, abilities, and knowledge that can indicate what aspects the administrator should make efforts on developing training program. Meanwhile, the administrator needs to change some common inappropriate notions of the teacher (e.g., it is impossible to cultivate the creativity of students) and enhances their confidence in creative instruction. The effect of this sort of training for teachers has been confirmed in many studies. For example, Trnova (2014) found that inquire-based science education (IBSE) improved the creativity of teacher participants. The development of teachers’ creativity in instruction should be promoted by the effective training.

FUTURE RESEARCH DIRECTIONS

In recent years, the research on creative learning and teaching has still continued all over the world, especially in Europe and North America. For example, Bob (2006) did contributions to summarize the previous research and practice on issues of creative learning and creative teaching. It should be noted that some publishers working on creative teaching have been developed; for example, Creative Teaching Press is such a publishing house that aims to publish books for readers who are between 3 to 14 years old.

Along with the exploration of theoretical studies, researchers also put more emphasis on the methods for developing creative learning and teaching, and they developed a series of practical courses, and even some special research centers or companies have been established. For example, The Center for Creative Learning and Teaching, the center located in Michigan State in the United States, is engaged in developing the practical courses and conducting the exploratory research among elementary children and disabled adolescents. In the Center for Creative Learning (CCLT), located in the state of Florida in the U. S., researchers led by D. J. Treffinger have applied the research results to the practice of creative teaching and learning, and developed individuals’ creativity and gift. Schools, governments, museums of art, scientific centers, even churches and international institutions of education have become the customers of CCLT recently. Accordingly, to combine research and social service became one of important trend in the research area of creative learning and teaching.

Another trend is to link creative learning and teaching with the Internet. With the rapid development of the Internet, the way of living, contact, and education has been greatly changed. In recent years, educators have attached more importance to the application of the Internet to teaching. Web-Based Instruction (WBI) such as remote instruction and web-based courses has become more and more popular.

The Internet has special advantages over other media for modern teaching and learning. B. H. Khan (1997) pointed out the following features of the Internet learning environment: interactive, multimedial, open system, online search, device-distance-time independent, globally, accessible, electronic publishing, uniformity world-wide, online resources, distributed, cross-culture interaction, multiple expertise, industry-supported, learner-controlled, convenient, self-contained, ease of use, online support, authentic,
course security, environmentally friendly, non-discriminatory, cost-effective, ease of coursework development and maintenance, collaborative learning, formal and informal environments, online evaluation, and virtual cultures, etc. So educators can teach flexibly, effectively, and creatively, and students can learn collaboratively and interactively with teachers, and exchange knowledge with peers between different cultures.

Therefore, Bonk and Reynolds (1997) stressed that by the web instruction, strategy of student-centered learning can be practiced. Students also can be improved abilities of creative thinking and critical thinking by techniques such as brainstorming, role-playing, creative writing, and case studies. Shi-Jer, Nai-Ci, Huei-Yin, Kuo-Hung, and Ru-Chu (2012) combined conventional classroom teaching with teaching blogs and encouraged to use a model of Asking, Thinking, Doing, and Evaluation (ATDE) to help teachers to generate new ideas and interact with students positively, and evaluate students more positively. They stressed teaching blog increased the interaction of teachers with students and improved students’ academic performance.

CONCLUSION

Although the research on creative teaching and creative learning has a history of almost 100 years, it still has a long way to go. This chapter tells us that creative teaching depends on creative teachers who are equipped with necessary abilities, notions, and attitudes. Necessary resources and training program should be provided to teachers in order to better development of their creativity in teaching experiences.

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**KEY TERMS AND DEFINITIONS**

**Brainstorming:** A group creativity technique by which a list of ideas spontaneously contributed by its members is gathered to find the best solution to a specific problem.

**Creative Learning:** The process in which learners acquire extant knowledge or “find” new knowledge by automatic exploration and creation.

**Creative Teachers:** Those teachers who teach in a new, original, and appropriate way. They encourage students’ free exploration, provide the open atmosphere for students, inspire students’ passion for creative learning process, and finally help to bring about creative learning.

**Creative Teaching:** A condition of developing creative learning. In the process of creative teaching, the teacher inspires learners’ interests in learning material, and then leads students to find the problem by themselves creatively, or present specific problems and ask learners to apply all sorts of available resources to find the best satisfying solution creatively.

**Creative Techniques:** The procedures that elicit the creative thinking of individuals or groups. Some creative techniques can be applied to creative teaching to train students’ creative thinking.

**Discovery Learning:** A sort of learning by which the learner draws on his or her own experience and prior knowledge and interacts with the learning environment by exploring and manipulating objects, or performing experiments to discover the truth behind the phenomenon to some extent.

**Innovative Learning:** A sort of learning with a similar meaning with creative learning, by which the learners elicit the change, renewal, reorganization, and a series of new questions.
Chapter 23

New Paradigm of Creativity: From Newtonian Mechanics to Quantum Mechanics and Higher Education Development

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ABSTRACT

The author aims to provide an alternative perspective on creativity in order to accelerate a paradigm shift in creativity in higher education. The perspective would enable every single person to extract the full potential and to contribute to society. Due to the idea of science: reproducibility, the main goal of research has been finding an ultimate solution that would be applicable to every single person. This idea comes from Newtonian mechanics; or, in other words, cause and result relation, that a specific factor causes a specific outcome. The problem of this idea is that Newtonian mechanics is designed for such objects as an apple and a car. Obviously, human thought, the main source of creativity, is not an object. This fact suggests the necessity of alternative approach. The author proposes a different perspective to change a paradigm of creativity in higher education.

INTRODUCTION

The purpose of this chapter is to propose an alternative perspective on creativity, the origins and enhancement of which have been a great concern, but have remained somewhat mysterious. The major mistake that we have made in thinking about creativity is that we have tried to apply Newtonian mechanics to human thinking and to understand it in terms of observable causes and effects. It is understandable that we still approach creativity in terms of Newtonian mechanics, with its focus on the observable world, in like manner as we approach physics and economics, because we instinctively tend to believe what we can see.

Indeed, interpretation is at times more important than discovery itself, because the way in which we see the world determines how we think that it should be. Great discoveries are often underestimated or even
ignored for fear of altering the way in which people see the world because new perspectives represent a potential challenge to existing beliefs. In this sense, the promotion of creativity might better be advanced, not by discovering new scientific facts or introducing new methods, but by providing opportunities for people to examine critically their current beliefs and encouraging them to consider other perspectives.

Therefore, the author’s main goal in writing this chapter is to offer just such an opportunity to reconsider what creativity is, its origins and how it can be fostered. The key concept for this chapter is that “The whole is greater than the sum of its parts.” For example, suppose that one’s current perspective is “A.” Acquisition of a new perspective, “B,” actually creates a new perspective toward “A” as well. Thus, learning “B” at the same time establishes another new perspective “C.” This chapter represents an attempt to bring about a perspective “C” by suggesting a perspective “B.”

BACKGROUND

For a long time, unlike other subjects, the research in creativity has not shared the common awareness that even the definition of creativity is different from one discipline to another. In the early 20th century, thanks to Werner Karl Heisenberg, science has experienced a paradigm shift from Newtonian mechanics to quantum mechanics. What is implied by the quantum mechanics was completely contradict to what people had believed. However, this great shift has had a huge impact on different fields including psychology and brain science. In the field of psychology, different approaches have been tried to understand what the human mind is and to figure out how it works. Before this paradigm shift, psychology was dominated by the idea of structuralism mainly led by Wilhelm Wundt. In short, structuralism is applicable to the idea of Newtonian mechanics with a premise. That is to say it is possible to deconstruct mind into different parts applying the cause and result relation. However, as the science experienced the paradigm shift, other approaches, like Gestalt psychology, which focuses more on the holistic function of mind, have emerged. From the late 20th century to early 21st century, cognitive science, which is interdisciplinary scientific research on the human mind and its function, has flourished applying the latest scientific facts in different fields. However, when it comes to creativity, due to its unclueness, the paradigm has been trapped in the idea of Newtonian mechanics. Especially, the foundation of current education system was designed in the industrial era with its main object reproducing people that would fit with social values rather than enhancing each individual’s talent.

MAIN FOCUS OF THE CHAPTER

Getting straight to the point, this chapter will argue for a new paradigm of creativity that can be described with the following equation: iT=bT: (Identity)(Thought)=(Belief system)(Thought). If creativity exists outside of the cause-and-effect model, we need to replace Newtonian mechanics with quantum mechanics in order to make any serious progress. Whereas Newtonian mechanics applies to objects, quantum mechanics applies to states. The change from a Newtonian to a quantum approach enables a paradigm shift in the perception of creativity. Creativity as we know it is dead. This is the rebirth of creativity. The objective of this chapter is not to find an absolute formula to make all of humanity significantly more creative, but to propose an alternative approach and to change the assumptions that underlie current ways of thinking about creativity.
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Without exception, human creation is generated in thought, not in any physical reality. To express something physically, it is necessary to use the body. To use the body, the brain needs to transmit a signal. Thus, all creativity occurs in the brain. Action will never come first unless we find a way to control the body without the brain. This means that creation is a phenomenon that is located in the brain, but that does not physically exist. By using fMRI, it is possible to see the electronic signals in the brain, but this kind of information does not explain the human mind and human consciousness. In fact, science has not yet truly understood the mind. The human body exists as an object that follows the laws of physics. However, our thoughts, the source of creativity, do not follow the laws of physics; a person can dream, imagine, or hallucinate things that defy the limitations of the physical world. What this tells us is that creativity is a concept, a thing that does not physically exist, but can exist only in thought. Thus, in order to understand creativity, we need to understand what thought is.

Thought is a state like a wave. No one can stop thinking. If someone could truly think about nothing, it is impossible to be aware of it. This fact suggests that thought continuously exists even in the absence of the awareness of a given moment. Thought is a state of information processing, and it can be embodied in verbal and non-verbal expressions. By embodying thought, it is possible to temporarily capture a fraction of the state as a wave. Thought like light has a wave–particle duality, meaning that it has the characteristics of both a wave and a particle. Thought is normally a wave, but when it is observed, it displays the characteristics of a particle. Quantum physics is designed to explain the kind of dynamic states in which thought exists, for which reason creativity can more usefully be analyzed in terms of quantum mechanics than in terms of Newtonian mechanics.

In sum, the main objective of this chapter is to propose an alternative approach by applying the concept of quantum mechanics, and necessarily assumes that quantum mechanics presents an accurate picture of the world. Thus, this chapter aims to apply the concept of quantum mechanics to creativity, rather than to generate mathematically a single, absolutely correct answer. Put another way, the attempt to discover a single correct answer applicable to every single person should be replaced by an approach that interprets holistically what creativity is.

Issues, Controversies, Problems

The first issue in terms of creativity is misperceptions about creativity. Misperceptions about creativity originate from failure to appreciate that it originates in the brain, and from failure properly to understand the thinking process. First of all, definitions of creativity or of being creative are not well formed, but are rather highly subjective and easily criticized. In particular, the discussion of ways to improve creativity tends to crowd out discussion of what creativity actually is. It is important to remember that ideas that were considered creative yesterday can seem unremarkable today, and that one idea can only be considered creative with respect to another. Nothing can be considered creative forever, but only within a given temporal context. Creativity is not embodied in a certain action or object but in a comparison and relationship.

Secondly, and by extension, ways of measuring creativity are also vague. For example, one of the most common criteria for assessing creativity is novelty, though the concept of novelty itself is comparative. It is for this reason that the simple act of copying what has been done before is normally not considered creative, although paradoxically, most attempts to improve creativity are based on the idea of reproducing what creative people do. Creativity is now considered some sort of skill or ability in which one can be superior to others or that can be strengthened by some regimen. This leads to the perception that it is
possible to measure creativity. However, it is often the case that the criteria used to measure creativity are based solely on comparison to someone or something. For example, in much of the research that has been done on creativity, the means to measure it is based on calculating an average value for a certain action or performance, such as the number of ideas that are conceived or how many problems are solved in a specific period of time. It is obvious that such measurements have nothing to do with the ability to create something, which would be seen as creative work.

Another issue is the current approaches to creativity. To review, modern approaches to creativity are based on Newtonian mechanics, which apply to objects and which are designed for exploring cause-and-effect relationships. The basic premise of these approaches is that creativity can be measured and quantified using specific criteria, and that it is possible to enhance creativity by discovering a single cause that would bring about the effect of creativity in every single person. As a result, many approaches seek the essence of creativity through experiments that, it is hoped, can reveal underlying structures in the form of traits shared by a specific group of people, or can yield observable and predictable reactions to specific stimuli.

However, as discussed, creativity does not exist in the field of the object but in the domain of a state, for which reason we need a disruptive shift in the perception of it. What has been thought of as creativity is dead. It is merely a name given to a thought phenomenon. Now, by shifting our focus to quantum mechanics, creativity experiences a rebirth. It has been believed that creation is the result of thinking, which locally reflects a person’s entire thought (his or her mind). This notion has led to the assumption that a certain piece of knowledge or experience is the source of individual acts of creation. However, creation is not a local expression of knowledge or experience, but rather a full expression of one’s self. Regardless of the form it takes, or the moment in which it arises, creativity springs from the entirety of one’s knowledge and experience. Even a single, minute act of creation draws on the entire life and all the knowledge and experience of the creator, in order to process information in a certain, new way.

These considerations lead to another crucial point, that, when it comes to creativity, we tend to focus only on what is expressed, and to ignore what is not expressed. The decision to express a particular idea or perspective is simultaneously a decision to eliminate other options. Without all of the information that remains unexpressed, not a single creative act could occur. In keeping with the experience of those working in the field of artificial intelligence, we find that the cause-and-effect model cannot easily be applied to human thought, which is not an object like an apple, but is rather a state like wave. The way we have approached creativity has been based on the assumption that a biological understanding of the brain would reveal to us how our cognition is generated. This is an approach to cognition that advances by accumulating observed behaviors and subjecting the data to statistical analysis. The human mind, however, is obviously something transcendent, and it is not the case that one piece of information always corresponds to one reaction in the brain, or that this cause-and-effect set is reproducible; the situation resembles more a network of information that in changing shape creates the mind as a result. In fact, it is possible to maintain one’s perception of being the same person after gaining or losing some information because consciousness is a network rather than the invariable sum of the information contained within itself. In fact, some events that have emotional impact change ways of thinking so dramatically that one can experience a transformation of one’s personality in a short period of time while maintaining the perception of being the same person.

It can therefore be seen that the transformation from one state to another is a sudden shift, a non-linear event, in which many factors interact simultaneously (Gendlin, 1978). Such a shift could not happen if the mind were simply an accumulation of memory; it is only because the mind is a network that one
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event can change all of the interconnecting patterns. Some approaches to creativity are focused more on generating this type of experience, one that would bring about a radical change in the way connections are made; but the basic underlying premise remains in the paradigm of Newtonian mechanics that seeks a cause-and-effect relationship. As a result, those approaches are designed to deliver an experience that would have the same effect and impact on the majority of people. However, each person possesses a network that is unique and separated from any other network and that defines him or her as a person. Thus, shared experiences naturally have limited impacts that last only a short period of time. Approaches that attempt to apply research in the field of neuroscience focusing on how the brain, as a biological entity, responds to a given stimulus. Here again, however, the aim is to identify a cause-and-effect relationship that would be universally applicable. It might perhaps be possible, with respect to neurotransmitters, to reproduce a specific reaction in the brain. What is really needed to effect change, however, which is not the transmission of signals in the hardware, but an understanding of the software that determines how the hardware operates.

As mentioned above, most modern approaches to creativity treat the conscious mind as a physical substance, and look for solutions in the realm of physical substances, rather than treating the mind as a field that can be altered through a change in perspective. There is a pressing need to rethink the stimulus-response, cause-and-effect basis on which most social science rests (Rogers, 1979).

SOLUTIONS AND RECOMMENDATIONS

First, it is necessary to understand better what is creativity. In short, creativity is a phenomenon. Creativity is a name given to a phenomenon that is but a very small part of thought, and for which we lack a clear concept. Thought is the process of connecting information. It is a state of connectivity of information in the brain. Creativity is a form of connectivity that has unique value in a specific moment. On account of the influence of existentialist thought, creation is often considered the act of generating something out of nothing, though in fact it is just the process of a change of state. As a result, it is generally and without reflection believed that something is generated in our thought at the moment of creation. This notion results in an attempt to measure creativity without regard to the fact that it is insubstantial and exists only in relation to other similarly insubstantial concepts, and therefore defies attempts to measure, capture or grasp it. Since science has advanced in step with advances in the means to quantify natural phenomena, the attempt to measure creativity is understandable. But it is important to remember that the criteria used to measure creativity, such as economic value and novelty, are equally insubstantial. It is glaringly obvious that it is impossible to measure something that has no substance by means of a scale that also has no substance. Furthermore, every facet of cognition, including information gained from the conscious and unconscious mind, is information that lacks substance. The brain simply receives data that has been gathered through the various senses and translated into sensory information, restructures it, and thereby generates a coherent reality. Even all the things that humans believe to exist amount to just a state of information. For example, we call the combination of H (hydrogen) and O (oxygen) water. Water, then, is merely a state of the combination of these two different elements. Each element can be further subdivided into smaller entities down to the level of subatomic particles. Everything in the universe in the end is a state of these vibrating particles. Humans have simply given a name to the states of these particles and believe in their existence. However, the underlying truth is just a state of information. Observing the universe on this level, everything is a phenomenon manifested in the mind, including the
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substance of observation itself. Under these circumstances, thought becomes a sub-phenomenon of a phenomenon that has no substance. It is just a state of information connected to a structured network. The more complex a system, the greater its potential for self-transcendence: its parts cooperate to reorganize it (as cited in Rogers, 1979, p. 7).

We cannot enhance or reinforce creativity in the way that the majority of people would expect owing to a systemic issue and a social issue. The systemic issue is that we cannot apply Newtonian mechanics to creativity, even though most of us are comfortable with this approach because we are so familiar with its applications to a wide range of problems in the natural and social sciences. What we have called “creativity” is not something that exists separately from thought, but is rather a kind of thought. This means that we cannot apply the absolute cause-and-effect model of creativity because thought is characterized by a wave-particle duality. The social issue here is that the definition of “creative” is not absolute, but is rather relative and variable. Ideas that are considered creative today might be unremarkable tomorrow because values change. There is nothing that is inherently creative. The desire to search for an absolute formula for reproducing creative acts that would be universally applicable is understandable, but this search ignores the basic fact that thought is not an object. In order to experience a quantum leap in creativity, humans need to alter their perception of it drastically.

To sum up, then, thought is a state of connecting information and a creative network that varies according to values that are also variable, for which reason Newtonian mechanics falls short as a mode of analysis. Behaviorism and structuralism seek a cause-and-effect relationship that can enhance creativity, but this approach is equally flawed, for the mere observation of actions and behaviors that people have considered creative offers little insight into how the relevant information is processed or connected. Each person has a unique set of reactions to various stimuli, and there are thousands of potential reasons why a person might react to a certain event in a certain way. For these reasons, it must be concluded that creativity is part of thought and is therefore not an object but a state, and will forever remain refractory to Newtonian mechanics.

A New Paradigm of Creativity

The principles of quantum mechanics provide important insights into the structure and nature of thought. Let us begin with the so-called “wave equation,” \( H\psi=E\psi \), in which \( H \) represents the Hamiltonian operator and corresponds to the total energy of the system, \( E \) represents the Eigenvalues which are the energy levels of the system, and \( \psi \) represents the inherent state. The purpose of the formula is to determine the quantum state. Attempting to understand the structure of thought is a process very similar to the aim of quantum mechanics, which is to describe a state rather than an object. Our goal here is not to solve the formula mathematically, but to apply the concept to creativity. The application of the formula here is intended to facilitate a new approach to understanding creativity at the meta-level. Unless we find a way to quantify the human mind, the quantification of creativity is not possible, which is why an interpretation of quantum mechanics combined with human mental processes is being offered here.

\[ iT=bT. \]

(Identity)(Thought)=(Belief system)(Thought)

Identity: “Identity” refers to the network of information accumulated in the brain.
Belief system: “Belief system” refers to the means by which information is ranked by the brain in terms of its relative importance.

Thought: “Thought” refers to a state of processed information.

By numerically solving this formula, it would theoretically be possible to determine an inherent state of thought, though this is not the objective here. The most significant difference from approaches based on Newtonian mechanics is that this quantum approach does not follow the cause-and-effect model. As a consequence, creativity, a type of thought, is not merely a part of the whole, but exists within the entirety of each person. The reason that both sides of the formula contain “thought” is that every single thought process represents the complete process of thought: “one is all, all is one.” Put another way, the definition of a single idea simultaneously identifies all unnecessary information. For example, it is possible to identify a specific point on a wave. Wave height, componential analysis of water, and temperature would allow for the quantification of a particular point of the wave, but cannot explain the complete phenomenon of the wave. An assessment of the entire environment is required in order to recreate a given state. This means that any point of thought/wave that might be selected is a representation of the whole. Here we find the most important difference from all the other modern approaches to creativity, which aim at deducing a cause-and-result relation, and therefore fail to grasp the entire picture of the thinking process. Unlike these other approaches that try to define the essence of thought, this approach simply sees thought as a state of information embedded within a framework.

In the above equation, “belief system” is as inextricably linked to “identity” as the ozone layer is to the earth’s environment. Neither can exist apart from the other. The belief system plays the role of the ozone layer: it determines the degree of importance of information, screening what information to perceive, what to leave out, and what to process. Identity, which in the analogy corresponds to the earth’s environment, is the entire network of information in the brain, including memory, through which the personality is constructed. The earth’s environment has developed by receiving energy from the sun and various rays from the universe, in the process creating the ozone layer. The ozone layer filters out a large portion of the energy from the universe and allows the earth to maintain its current state. The environment both creates and is shaped by the ozone layer; neither can exist independently. Especially in Western countries, which tend to have a highly developed concept of the spirit or soul, there is an underlying belief that identity is not influenced by external factors. However, if the brain is merely an organ for processing information, what is understood as identity would simply be a network of information. The idea of this chapter is not to debate the existence of the spirit, but to propose a perspective from which to view human creativity in a holistic manner. So, whether or not identity exists independently from the spirit or not, we shall see that identity is built on information and exists within a web of relationships to external factors, which is best described as a network.

To repeat, then: thought is a state that cannot be captured in its entirety; identity is a function of the entire memory; the belief system is a screening system. What we can do is to change two aspects of thought: the nature of the information that is to be connected and the manner in which it is connected. Without solving the formula, it is not possible to capture thought itself. Further, identity is a function of life in its entirety, and therefore cannot be controlled. What is possible here is to change the belief system, which is the process of screening information? By changing the screening system, one can alter what information is subject to cognition, processing and expression. This alteration, in turn, offers a new approach to creativity. Again, a mathematical understanding of thought is not necessary in order to
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change the way information is linked and processed. For example, in the 21st century, everybody uses computers and smartphones, but only few people have the engineering know-how to explain the role of each small piece works in such complicated machines. However, an understanding of software allows one to change how a computer or smartphone operates. The same idea is applied here. Understanding transcends explanation

Evolution of the Screening Process

It is often the case that people believe that they see the world as it is, even though one can perceive only a small part of it due to the brain’s screening system, often referred to as the RAS (Reticular Activating System). This system allows humans to focus on specific things in order to detect immediate dangers. For example, one can maintain a conversation in a noisy environment. However, at the same time, this screening process renders most things invisible, as if they did not exist. This system helps the brain prioritize the information it receives in order to focus on that information which is necessary information for survival. If it is not able to recognize the things in front, they essentially cease to exist in one’s world. That is why changing the screening system changes the quality of creation drastically by changing those things that are to be recognized and processed. There are two targets for the changes advocated here: the conscious screening process and the unconscious screening process. In like manner, there are two ways of altering the screening process: an external approach and an internal one. Modern approaches are concerned with altering the conscious screening process using an external approach, even though it is said that 95% of our thought is unconscious (Kahneman, 2011).

Unconscious and External

This approach is called brainwashing; people are not aware of the fact that their belief system has been constructed in response to other people’s wishes. The best known example is the education that parents give to their children. What is told to children is not necessarily what they truly need, but what the parents want them to learn. Children normally follow what they are told by their parents in order not to lose their love, since losing their love could lead to death. For a small child, getting as much love as possible is a major concern. That is why the belief system constructed during the childhood is relatively difficult to change: it is emotionally tied to the developing personality. On the one hand, brainwashing can target a specific people, such as children or military personnel. On the other hand, brainwashing can happen at a social level, where it is expressed in ideas like common sense and various ideologies. In either case, the subjects’ ways of thinking are oriented in a specific direction and controlled on behalf of authority. Returning to the role of education, it may be observed that, for example, even though memorization of names of historical figures does not necessarily foster the ability to think conceptually or to shape positive values, it serves to imprint a specific pattern of thinking and to develop a personality which is preferable for a given authority. The reason that it has proved so difficult to reproduce social structures such as the culture of Silicon Valley or more specifically that of a company like Apple is that each person is already equipped with the screening process that has been created by his or her environment. Conflicts between two groups, up to and including war, may usefully be described as battles between belief systems (Usó-Doménech & Nescolarde-Selva, 2013). As many education systems requires a decade or more, changing the unconscious screening process externally requires a huge effort in order to change all of the existing rules or system.
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Conscious and External

There are two possible directions for this approach: prescribing the screening process and weakening the screening process. Corporations that want their employees to think in a particular way mainly for the sake of business often attempt prescribing the screening process. This is process based on the idea of focusing on a specific process and aiming for expected results by following the process. Systematic approaches and methods like design thinking and innovative thinking aim to alter the conscious screening process by prescribing the screening process in a certain way. By doing so, one would be able to perform as expected to some extent. However, the degree of alteration is delimited by the prescribed processes and by the pre-existing information in the brain. Further, this approach can direct a person to think and behave in a specific way for only a quite limited period of time. The outcome is also completely dependent on each person’s willingness to follow the procedures and to maintain awareness of them. Also, in order to achieve an expected result in a different type of situation, it is necessary to install different screening processes. Another possible approach is the use of psychiatric medicines to weaken the screening process. For example, as a research of Giovanni Petri (2014) shows, the drug psilocybin weakens the screening process by which information is connected, creating different results from those usually produced. As a result, one would experience a completely different way of screening and connecting information. Medication would bring about a temporary but immediate effect. However, it requires a proper environment and adequate knowledge to achieve a result, and thus, it is hardly applicable to the majority of people.

Conscious and Internal

In this approach, an individuals control their conscious behavior by controlling their conscious thought. This is often called “will power,” and it is often ineffective, or effective only for a limited time, because our unconscious dominates the decision-making process. Conscious, internal change usually requires some drastic change in one’s environment, or a literally life-changing experience. This approach therefore relies on a luck and external factors to some extent. Otherwise, the conscious decision-making process is easily influenced by emotions and unconscious thinking patterns. For example, everybody knows that smoking is unhealthy, but it is hard for smokers actually to quit smoking due to unconscious thought patterns. Needless to say, nicotine, like alcohol and other mind-altering compounds, induces brain chemicals such as dopamine and serotonin, so there is much more involved than simply the screening process. Viewed from a neurological perspective, “good” habits are those that have a positive effect on health by sideling detrimental and unnecessary processes more at the level of the unconscious than conscious thought. However, since the main purpose of will power and creating habits is to limit the information processed by the current screening process, this approach generally fails to generate a significantly better outcome.

Unconscious and Internal

This approach, which targets the unconscious screening process and attempts to make a radical change to the screening system, has limitless potential to transform the screening system because it is motivated by one’s inner desires. Goal setting and affirmation play important roles in making this approach effective. The aim of goal setting is to change the degree to which outside information is screened, allowing for an accordingly different manner of cognition. Affirmation aims to alter the internal evaluation system; its primary criterion is meaning. So to be clear, this process is driven by one’s own desire, and it helps
to develop a belief system that has different screening processes, while goal setting alters the degree of importance that one assigns to the information out of which the world is perceived and is made recognizable. The purpose of affirmation is to remove any mental limitations that have built up within the mind, often over a long period of time. A person’s inherent self-directive processes promote greater self-differentiation, more efficient self-regulation, self-understanding, and acceptance (Ryan & Deci, 2000). Rogers utilized the construct of the “actualizing tendency” to describe an organism’s motivation to realize and enhance its inherent potentials (Goldstein, 1940; Rogers, 1959; Bozarth & Brodley, 1991).

What the approaches and methodologies discussed above are able to alter is the process by which information is screened. Changing the screening system, or belief system, changes the types of information available to the conscious mind, and the ways in which information is processed and expressed. From a practical standpoint, there are still two significant factors to consider with regard to these methods, the external and the internal. The external factor to be taken into account is that social and economic values always depend, to some degree, on the consent of other people. Thus, what seems objectively to be great progress and invention can be useless if it does not conform to an individual’s social and economic values. Turning to the internal factor, the fact is that creation itself is limited by the amount of information (knowledge and experience) each person has. For example, even an exceptionally creative child cannot design a working rocket. Changing the belief system widens the range and quality of information available and how that information can be connected. Inasmuch as the maximization of one’s potential is strongly linked to one’s perceived value, the possibility of change remains tied to social and economic factors. So it is that the maximization of potential is not necessarily an accurate indicator of economic success, which remains a variable quantity. Maximization of potential is rather a matter of increasing one’s opportunities. We need to accept this fundamental fact in order to move forward, even only a single step, instead of embarking on a frantic search for the absolute solution.

In order to accelerate the fourth screening process mentioned above: unconscious and internal, to maximize one’s potential, there are 3 aspects to discuss: goal setting, affirmation, and the perception of time. Since the focus of this approach is on unconscious screening process, it is not a framework or systematic thinking process that can produce a similar outcome. However, the result in the long term would bring about far much greater value to society than simply imprinting a certain model on people.

One: The Importance of Goal Setting

In fields like sports, goal setting is clearly recognized as an important factor in achieving a performance target. However, in general, especially when it comes to creativity, the significance of goal setting has long been underestimated amid the understandable attempt to identify the one right way to engender or enhance creativity for the reasons mentioned previously. Scientists easily fall into this trap when they seek a cause-and-effect relation in the field of creativity based on the assumption that a certain stimulus or environment would make a person more creative. It is obvious that certain environments would be conducive than others to thinking or imagining more freely, but focus on the environment fosters a tendency to overlook an important aspect of the human experience. For if, in fact, the same stimuli were administered to the different people, responses would differ from person to person, even among people sharing the same environment. Unless we can explain why the response to the same stimulus differs in this manner, it will be impossible to maximize talent and potential, and for this reason we need to think more about how cognition works. As Dr. Hideto Tomabechi (2011) mentions, our cognition is generated by goals and objectives. For example, the main goal of most animals is to find food, and most animals
spend most of their time trying to achieve this goal. Humans were equally driven by the desire to find food at the time when there was no civilized society. Without any weapons, it was nearly impossible for humans to hunt large animals such as mammoths, but the incredibly strong desire (goal) to acquire food to survive induced them to conceptualize different options, to come up with unique ideas, and inevitably to create stone implements. In other words, the existence of an objective corresponding to an inner desire changes one’s cognition in order to achieve the objective, allowing one to consider more options and approaches. Whether we are speaking of a flower or an oak tree, of an earthworm or a beautiful bird, of an ape or a man, we would do well; I believe, to recognize that life is an active process, not a passive one. Whether a stimulus arises from within or without, whether the environment is favorable or unfavorable, the behaviors of any successful organism will be directed toward maintaining, enhancing, and reproducing itself. This is the very nature of the process we call life (Rogers, 1979).

It is obvious that this point has been ignored in the discussion of creativity. An experiment conducted on 60 people selected at random to join a workshop given by the author is instructive. In order to remove cultural biases, the experiment included subjects from Italy, the Netherlands, Spain, Russia, Germany, Colombia, Mexico, Brazil, Israel, Turkey, Egypt, South Africa, Lebanon, Japan, India, Hong Kong, Canada, and the United States. In order to curb expectations, the subjects were not given any information in advance before being told to memorize, in 5 seconds, what they saw in a picture in which many different objects were depicted. Even though one of the biggest icons in the test picture was the symbol for the Japanese yen, only 10% people noted this icon, though the subjects often listed the icons of Google, Facebook and Yahoo that were 30% to 40% smaller than that of the yen. So despite the fact that Japan still boasts the world’ third largest economy (though its gross domestic product, GDP, decreased by $303 billion in 2014), 90% examinees failed to identify the symbol that represents Japanese currency. This result suggests that people can perceive information that is important to them, rather than what might seem to be important based on objective criteria. In a similar experiment (Simons & Chabris, 1999), test subjects were asked to watch televised basketball games between two teams of three players and to count how many times a ball was passed between the players of each team during the game. When the subjects were thus engaged in watching the games, they failed to notice an actor dressed as a gorilla who walked slowly across the screen. Such experiments show that humans perceive only a limited amount of information according to the degree of importance that assign to it. This degree of importance is directly connected to one’s objective and goal. Setting a clear goal and objective facilitates a reassessment of the degree of importance, and thereby alters the field of cognition. Things that are not assigned a threshold level of importance for all intents and purposes do not exist. For the brain, everything is merely information to process. Modern approaches spend a great deal of time discussing ways in which information that has been given attention is manipulated, but relatively little attention is given to the fate of information that does not find a place in conscious thought. A useful analogy is taking a picture: purchasing the best quality cameras equipment would be useless if there is nothing worthwhile to photograph. When the photographer focuses on a specific object, however, various paths to the goal of creating a meaningful picture become evident.

As discussed in the previous section, all people as long as they are part of a society, are shaped by education, which is often mandated by a government, into a defined way of thinking, even if they remain unaware of the fact. In terms of creativity, the screening and processing of information in a way that conforms to one’s characteristics and disposition in order to achieve one’s goals, is strictly limited by the pre-installed screening system that is the education system, and that is designed to maximize benefits for society rather than to realize an individual’s potential or talents. The biggest obstacle to setting an
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objective for realizing one’s full potential or talent is this effect whereby the screening system installed by society hinders recognition of an ideal objective because even the act of identifying one’s ideal goals takes place within the screening system given by society. In the industrial era, it became convenient for industrialized societies to have people think and behave in the same way in order to maximize control and to maintain order. It is no longer effective to manage people in this way because there are currently an estimated 53 million Americans freelancing, approximately 34 percent of the total workforce (Forbes, 2015). One of the most common sources of resistance to allow every single person to set his own goals is that this would diminish the harmony and organization of society. However, as the US has continued to experienced grown in GDP despite the fact that 34 percent of the workforce is freelancing, it is no longer true that society needs to make such sacrifices in order for each person to determine his or her own goals. Nevertheless, corporations and organizations remain especially concerned about losing capable employees if these employees are allowed to set their own goals. Unfortunately, there is no reliable data on the correlation between goal setting and resignation, so the issue cannot be resolved at the present time. However, it is reasonable to conclude that employees whose goals are set by a third party would be less likely to make the most of their talents or potentials. If workers were naturally motivated by their own desire, there would not have been so much research on motivation. It is not exaggerating to say that what corporations and organizations need to keep in mind regarding this point is how to keep attracting capable talents rather than attempting to control employees and causing a concomitant sacrifice of their talents.

It is especially important, in terms of human capability development in the twenty-first century, to move away from the goal of controlling and managing people to that of collaborating with people and helping them to realize their potential. Along with the advancement of technology, According to data provided by Internet Usage Statistics, more than 42% of the global population has access to the Internet as of December 2014, which represents and increases of 753% since 2000. In North America and Europe the Internet penetration rates are particularly high, 86.9% and 70.4% respectively. This situation suggests that an individual can access more or less any kind of information instantly and in a relatively easy manner. As can be seen in the case of some of the role that social media played in revolutions in the Middle East and Africa, the more that people have access to information, the less easy it is for governments to control their citizens. Along with the pervasiveness of the Internet, more ways to work and live, such as telecommuting, have become possible. In fact, 79% of respondents to a recent poll indicated that they currently work outside of their company’s offices at least one day per week, and half said that they would like to telecommute more often, with the ideal frequency being 2-3 days per week (PGI Global Telework Survey, 2015). Unlike in the past, workers today seek more freedom in how they work and how they use their time during work. In fact, high tech companies such as Facebook and Google have started providing their employees with meditation courses in order to facilitate self-discovery and personal growth. The 21st century is a century of self-actualization. The clear difference between the way of setting goals proposed here and typical goal setting is the need for workers to be very honest with themselves in establishing personal goals apart from any goals instilled by a third party such as a school, company or family.

The main reason most people struggle with creativity is that they try to force themselves into being creative in a context in which they are required to be creative by someone such as an office supervisor. As mentioned above, goals affect cognition according to one’s fundamental desires. If one is asked to be creative for unfavorable reasons, one’s mind tends to generate reasons not to be creative, because avoidance becomes the fundamental desire. This process is called creative avoidance, the subconscious act of
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using one’s imagination to prioritize peripheral tasks in order to avoid taking action on more formidable and important tasks (Faxon, 2014). One of reasons that modern approaches to creativity are ineffective is that they miss the crucial point that people immediately set counter-goals of their own whenever they are required to set goals instead of being allowed to follow their personal desires. Again, most modern scientific approaches to these problems try to deduce a cause-and-effect relation by looking to the results, rather than to the process itself. Such an approach would be effective when it is for objects like an apple, to return to an earlier analogy; but when it is applied to non-objects like thought, it is important to consider as well what is not expressed. Setting objectives of observation makes it a scotia that the subconscious becomes creative to avoid to work on unfavorable given goals. The reason is that this is not expressed as a result observed, since the focus of observation is elsewhere: on goals imposed externally. Another difficulty that goal setting faces is that when goals are externalized, they are transformed into obligations, even if they were originally set according to pure desire. In particular, when goals are shared with others, they take on greater power, since members of the group subconsciously begin to equate these goals with being judged and evaluated by others. Even the act of committing goals to writing carries with it the fear of failure to achieve the goals. So when one externalizes goals, either by sharing them with others or simply writing them down, there may be the positive effect of discouraging procrastination, but there is also a negative effect on creativity because the motive for action becomes transformed from a desire to achieve into a fear of failure and obligation. Writing and sharing goals are also based on the Newtonian aim of identifying the exact cause-and-effect relationship. For these reasons, goals that are set externally and those that are shared both have the effect of hindering creativity.

Thus, the preferable way to set goals is to reflect on a truly desirable state in which one can feel mindfulness absent either preconditions or evaluations by others. The greater this awareness, the more surely those who seek to be creative will float in a direction consonant with the evolutionary flow of motivations and ideas. When people are functioning in this positive way, they are not self-consciously aware of all that is going on within their minds, like the centipede whose movements were paralyzed by becoming aware of each of his legs (Rogers, 1979). This way of goal setting diminishes the influence of the Reticular Activating System by which the information that structures the sense of reality is altered. Changes in the quality of information that are processed naturally alter the quality of the outcome. In addition, establishment of circumstances in the brain in which the frequency of creative avoidance is significantly lowered brings about a shift in focus toward processes conducive to achieving the goals. In the old paradigm, as we have seen, researchers were striving to find the absolute formula to enhance creativity. In this chapter, by contrast, the primary focus is on bringing about a holistic internal change without changing external stimulation or the environment. The focus here is partly based on the person-centered approach, which privileges the vast resources for self-understanding, for altering basic attitudes within the self, and for self-directed behavior, and which insists that these resources can only be tapped if a defined set of positive psychological attitudes can be instilled (Rogers, 1979). The aim here is not to enhance one’s capability or ability to deliver something, but is rather to adjust one’s way of encountering reality and altering the way in which information is processed according to the inner desires of each individual. The individual in this nurturing climate is free to choose any direction, but naturally selects positive and constructive ways. This actualizing tendency is seen to be operative in the human being (Rogers, 1979).

Nonetheless, for those who have been put through the existing education system and have installed the screening system that is created and reinforced by society, it is extremely difficult to identify the most preferable circumstances, or to be truly honest with oneself regarding one’s own desires. The mind with
the screening system given by third parties often runs up against impediments to thinking freely. What being creative means in the new paradigm is not coming up with more ideas or thinking differently from others, but connecting the dots in one’s own way in accordance with one’s goals and subconsciously transcending society’s screening system. As discussed above, more than 95% of thought comes from the unconscious, and thus it has been extremely difficult for most people to escape their habitual thinking patterns. For instance, amnesiac patients, who exhibit severe or total loss of the ability to recall previous experiences explicitly, nevertheless retain sensitivity to past experiences of which they are not conscious (e.g., Warrington & Weiskrantz, 1968). Such findings suggest that the habitual patterns have an enormous impact on thought. When criteria of worth are imposed on an individual from without, his or her self-image is often low. Exposure to overprotective or authoritarian environments can also have a similarly negative impact on self-image (Seligman, 2006). It is at the moment that it addresses the unconscious that thought becomes conscious, for which reason it is necessary consciously to impose changes on unconscious thinking patterns if we are to begin setting goals based on pure internal desire.

Two: Affirmation

Information connected with language naturally plays a significant role in how people understand the world around themselves. Self-understanding is also a function of language. People acquire values and norms based on the language used by others. Language, in other words, frames the meaning of the reality that each person creates for him- or herself.

Arthur Reber, in a classic series of studies conducted in 1967, first suggested that learning might be “implicit” because people appear to be able to learn new information without intending to, and do so in such a way that the resulting knowledge is difficult to express. Implicit learning contrasts with implicit memory in that the former typically involves sensitivity to relationships between events rather than sensitivity to single events, and contrasts with subliminal perception in that it typically involves supra-liminal stimuli. These considerations suggest that repeated use of words, which have positive meanings, would have a positive influence on unconscious thinking patterns, leading to the formation of a new framework with which to process information. It is the mental frameworks imposed by third parties that present particular impediments to thinking freely.

Affirmation is a technique often deployed in the field of coaching as a means to cultivate higher self-esteem and self-efficacy. We apply this method to the field of creativity because it is often difficult to break the mental barriers, which hinder unconfined thinking. Each person has a frame of reference for understanding reality and dealing with it that is structured as children mature into adults through education. Since the main objective of education is reproducing people who think in the way that the dominant authority prefers, one’s own desires may become restricted to an extent that disrupts the ability to think freely. People are often told to “think outside the box” in the field of creativity, but this begs the question of what “the box” actually is. What actually hinders people from thinking freely is the pattern of thinking and the screening system that limits one’s ability to come up with interpretations and connections. The screening process installed by society works so well that one thinks in a specific way even without any authority there to observe and enforce. In Discipline and Punish: The Birth of the Prison (1979), Michel Foucault used the term “bio-power” to describe how behavior is restricted by an external pattern of thinking. This power and the system that enforces it are incredibly beneficial in terms of maintaining order within a society, but this benefit comes with the sacrifices of individuals’ particular ways of thinking that optimally would originate in one’s own screening process. Given, then,
that there is some kind of box inside the mind, the question is how to break out of or to restructure in order to escape external strictures that stifle free thought. However much people are allowed to set goals freely for themselves, the range of goals would be delimited by the information that is shaped by the screening system and its associated pattern of connections if the screening process given from outside remains active. For example, in the workshops conducted by the author, participants go through an exercise in which they are asked to imagine their own ideal reality. They are told, “imagine that there are no limitations and that all possible resources are available, what would be your ideal reality?” In every single workshop, participants respond with questions that start with “can I imagine…?” even though attendants have been clearly told that there is no limitation on what they can imagine. This response is again mostly because the objective of education is to restrict and limit behaviors and thought in order to maintain the social order. Further, every group, whatever its size or type, requires its members to obey some rules and regulations. To maintain the harmony of society, individuals have been forced to sacrifice their own desires in order to think and act in specific ways that are beneficial to society as a whole. As mentioned above, once this pattern is established, it is extremely difficult to escape, since the bio-power functions even if we remain unaware of it. In order to get out of this frame of thinking, even momentarily, Milton H. Erickson (Erickson & Rossi, 1981) worked in the field of hypnosis on ways to use language to weaken the habitual frameworks.

As indicated above, the main hurdles for people seeking to utilize their potential fully are the frameworks that have been imposed on their thinking patterns. Unless deleterious frameworks are deactivated, any new methods would be doomed to failure. In terms of creativity, the most important thing is to foster a sense of confidence in being able to create or conceptualize ideas regardless of their feasibility. In fact, great creations by definition took shape before such things yet existed in the world, well-known examples being the TV, smartphone and computer. So the first step toward liberating thought is the creation of a conducive thinking pattern. That is why affirmation is an effective way to structure a thinking pattern that embraces thoughts that may seem illogical or non-practical. Affirmation of one’s self-worth is designed to heighten self-efficacy and self-esteem: saying yes to oneself. As the saying goes, ‘yes set’ can also be used to diminish resistance and, in those intellectual types who constantly analyze everything that is said, it can help to disrupt antagonistic logical frameworks (Battino & South, 2005). Constantly saying “yes” to ourselves weakens the patterns imposed on us as grew up. An individual who has been exposed to positive feedback that is largely conditional can have low self-esteem and feelings of worthlessness. An individual who is self-actualized will be more open to experience and less defensive, will learn to live in the moment, will trust own decision-making skills, and will have more life choices and be more creative. (J & S Garrett Pty Ltd, 2010). Since overt and silent negative speech interactions play a pivotal role in the onset and continuation of depressive and anxiety-related symptoms (e.g., Nolen-Hoeksema, 2000; Watkins, 2008), just saying “yes” to oneself itself has positive impacts apart from changing patterns of thinking. That is to say, intentionally exposing oneself to unconditional positive reinforcement can increase self-esteem and feelings of worth, and constitutes a first step to thinking freely.

Additionally, one’s understanding of the world is constructed mainly through the meanings given by language. For example, rules and regulations can affect how concepts are rendered into language. Indeed, people rely on language even when doing simple things like distinguishing patches of color (Boroditsky, 2011). The extent to which language shapes thought is not our concern here, but these considerations serve to remind us how great an impact language has on thought and in particular on the meaning that we give to the reality we perceive. Because they are encoded in language, experiences become confined to a certain meaning that gradually structures the mental map. For example, a failed attempt to do
something might be labeled by the word “failure.” However it could alternatively be interpreted as part of a larger process that leads to success. The same experience can contain and imply different meanings according to various ways that it might be encoded into language. A given meaning might be reinforced by emotion, which can work to encourage us to remember and avoid similarly problematic situations in the future. Therefore, by intentionally changing the language with which one thinks, one can generate different frames of reference for understanding the world, as it is perceived. Studies have shown that changing how people talk changes how they think (Boroditsky, 2011). It is particularly important, in order to disrupt habitual frameworks and patterns of thinking, to start thinking without any limitations, and it is imperative that we each build up a pattern of thinking which helps, by virtue of the words we choose to think with, to construct beliefs that are conducive to thinking freely. It is imperative that we allow ourselves to leave behind our habitual, discriminating and dualistic mindset if we are to have a meaningful encounter with other people and their worlds of meanings (Witty, 2007). Without such openness and flexibility, the habitual framework will impede free thought and imagination that, for the reasons set forth above, are necessary in order to set meaningful and advantageous goals.

**Three: Perception of Time**

At the same time that one is seeking to diminish the effects of the habitual framework in order to facilitate thinking freely, and is setting goals oriented by the internal pure desire, it is important to change one’s perception of time in order to encourage creative thinking. A consideration of how we perceive time will serve to review the concepts discussed in this chapter and to deepen our understanding of their significance. As mentioned above, the meaning of words that are repeatedly used in the mind and that structure one’s mental framework and belief system has an enormous impact on one’s thought. That is why affirmation is crucial if one is to change the screening system in order to set one’s own goals. Moreover, the perception of time also plays an important role in how one interprets and reacts to the present.

In the 21st century, the theory of quantum mechanics is largely accepted, but people still live with the perception of time associated with Newtonian mechanics. What quantum mechanics suggests is that there is always uncertainty in the universe, and that the act of observation itself has an influence on the result of observation. Late in the 20th century, Gregory Chaitin, who argued that all corollaries could contain elements of randomness, applied this principle to mathematics: “In a nutshell, Gödel discovered incompleteness, turing discovered incommutability, and I discovered randomness ”, as what Chaitin (1999) quoted as saying. This means that the physical reality that can be perceived through various means, including mathematics and physics, is not bound by destiny: possibilities are unlimited because we cannot determine the future based on the past. It is crucial to keep this fact in mind in order to make the most of one’s creativity, because people often tend to diminish their potential for creativity by measuring possibilities in terms of their experiences in the past and their common sense in the present. If the future were predetermined and inescapable, how would it be possible to maximize one’s creativity? Importantly, as has been said, most great human discoveries and inventions are based on ideas that had not yet happened when they were conceived. In other words, those who make things that are considered highly creative think or imagine things that did not exist until the moment that their revolutionary ideas occurred to them. So, if he is caught up in the perception that what he has done in the past and his circumstances in the present are what will determine the future, he will be unable to think freely and to orient his thought in a direction that will lead to new ideas in the future, and all of his goal setting and affirmation will be meaningless. Therefore, in order to nourish one’s creativity, it is necessary to accept
what has been proved by science and physics and to change one’s perception toward the possibility in the future.

The main reason for the notion that the past and present determine the future is the perception of time held by most people, especially in Western countries. This typical notion that time flows from the past to the present to the future, that it is linear and originates in the past. This notion is understandable because the religions largely accepted in Western countries are monotheistic and based on the idea of a god creating the world. Thus, it is a common perception of time that it started at the moment when God created the universe and began moving toward the future. This notion is also convenient for institutions that are endowed with authority to endorse and validate their power over the citizens as something rooted in the past and inextricably connected with the present and the future as well. I want to make clear that the objective here is not to debate the merits of various religious beliefs, but to become cognizant of how these beliefs may influence attempts to exploit the power of the brain. In order to enjoy one’s creativity, one’s perception of time often needs to be updated.

In short, it will be useful to think of time as something that flows from the future toward the present to the past, in contrast with the notion just criticized, that the past is the cause and the present is the result (past present). This notion is bound up in Newtonian mechanics; in the new paradigm of creativity, by contrast, quantum mechanics challenges the idea of linear, progressive time. From this new perspective, it is possible to define the past only through the observation in the present. This point was made in the famous thought experiment known as “Schrödinger’s Cat”, which demonstrated that the act of observation could determine the result. For example, if a person loses his grip when grabbing a glass, it may fall to the ground and break, and, the common sense explanation connects the cause of the loose grip with the effect or result of the broken glass. However, it is possible to define the relationship between two events only through observation in the present; in this case, the observation of a glass breaking points backward in time to the act of losing grip. From the perspective of thought, the present is the cause and the past is the result. The common sense causal relation is inverted. If the present is the cause and the past is the result, then time should flow from the future toward the past. To grasp this notion, it would be helpful to imagine standing in the middle of a river facing upstream. Suppose that the water is time, which flows from the future upstream, passes by the present, and makes its way downstream to the past. Thinking of the future, of things that have not yet happened, while inhabiting fully the present moment and with a firm understanding of the past - this is what it means to embrace every possibility. In the twenty-first century, when quantum mechanics has become widely known, changing perception of time is a minimum requirement for stimulating creativity.

FUTURE HIGHER EDUCATION DEVELOPMENT

The future of research in this field needs to cover functionality of mind especially in relation to creativity. The main focus of most of current approaches and researches on creativity is “how to make people creative”. This approach would be welcomed by authorities, which intend to force people to be creative on their own behalf. In order to extract true potential of each individual person, what is more important is “why people become creative” and “when they become creative”.

When observing human history particularly in the field of science and research, its prime focus is likely to be investigating structures and systems as Newtonian mechanics is to clarify the relationship between the cause and result. But, as it is mentioned in the beginning, human mind is not an object that
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can simply adopt the idea of Newtonian mechanics. It does not simply work under the same system as objects. In that sense, this chapter suggests not only a paradigm shift in creativity, but also a paradigm shift in the mindset of authority, which determines what students learn according to its demands. The design of education needs a significant change. It has to be human centered design whose prime focus is to allow one’s own self-realization rather than teacher centered design whose prime purpose is imprinting convenient model on students.

CONCLUSION

At times it is difficult for people to accept new approaches especially when they potentially deny the existing theories or approaches. However, it seems obvious that changing a paradigm in creativity in higher education are minimum requirements in the 21st century considering the science facts mentioned in this chapter. Instead of striving to find an ultimate formula that would make everybody creative, it is necessary to rethink how to extract the full potential of individual persons -regardless of any immediate economic impact. In the long term, this approach will allow the human society to flourish to a maximum extent.

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**KEY TERMS AND DEFINITIONS**

**Affirmation**: To affirm oneself, one’s capability and worthiness through using words that have positive meanings.

**Creativity**: A form of connectivity that has unique value in a specific moment.

**Education System**: A frame of learning experience by which specific information preferable for authority is imposed on learners.

**Goal Setting**: To set one’s own objectives and directions that are not influenced by someone’s values.

**Newtonian Mechanics**: A system of mechanics based on Newton’s laws of motion that is applicable to objects.

**Paradigm Shift**: Radical change in underlying beliefs or theory.

**Quantum Mechanics**: A branch of mechanics, based on the quantum theory used for interpreting the behavior of elementary particles and atoms.
Chapter 24

Going Towards Adaption, Integration, and Co-Creation: A Conclusion to Developing Creative Problem Solving Skills in Higher Education

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ABSTRACT

As a response to the growing challenges brought about by complexity in professional practice, the collection of chapters in this volume guides an intellectual journey through the various theoretical perspectives, research methods and pedagogical models with a focus on developing creative problem solving skills in higher education. Based on an overview of topics in this volume, this chapter aims to draw a conclusion about future research directions from present contributions. It could be an extended journey with the intention of helping the audience to locate the ideas presented in this volume within a framework constructed by the three main themes of adaption, integration and co-creation. This lays a stepping-stone in paving the way of pedagogical development and research prospects.

INTENTION OF CONCLUSION

As a response to the growing challenges brought about by complexity in professional practice, the collection of chapters in this volume guides an intellectual journey through the various theoretical perspectives, research methods and pedagogical models with a focus on developing creative problem solving skills in higher education. Based on an overview of topics in this volume, this chapter aims to draw a conclusion about future research directions from present contributions. It could be an extended journey with the intention of helping the audience to locate the ideas presented in this volume within a framework constructed by the three main themes of adaption, integration and co-creation. This lays a stepping-stone in paving the way of pedagogical development and research prospects.

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AN OVERVIEW OF THE VOLUME

There are around 50 authors who contributed to this volume and who come from 13 countries including Denmark, the United States, New Zealand, Germany, Luxembourg, France, Spain, Italy, Thailand, Algeria, India, China and Australia. The discussions deepen theoretical understanding and show diverse pedagogical approaches to developing creative problem solving skills in higher education. This involves many topics such as creative learning approaches, thinking methods, curriculum design, distance education, and professional identity, etc., which generate multiple angles from which to unpack the box of creative problem solving. This also involves a number of areas in higher education such as science, management, engineering, arts, biology, medicine, etc. Accordingly, a global view of common interests in developing creative problem solving skills in higher education can be generated from the collected chapters that meanwhile indicate the various pedagogies in different cultures.

Apart from underpinning the necessity and potential strategies to foster creative problem solvers in higher education, common interests may be found in the discussed topics, such as general instructional models (e.g., Chapters 9, 10, 11, 12 and 13), discipline-specific creativity education (e.g., Chapters 2, 3, 4, 5, 6, 7, and 8), problem-based learning (PBL) (e.g., Chapters 14, 15, and 16), online technology (e.g., Chapters 17, 18, 19, and 20) and deeper theoretical reflection (e.g., Chapters 21, 22, and 23). However, diversity is also revealed by those topics. For example, when the general instructional models are explored, Chapter 9 shows a particular student program, Chapter 10 shows an example of a transdisciplinary approach, while Chapter 13 shows how to employ the Torrance Incubation Model (TIM). Chapters 4 and 5 are both focused on teaching creativity to engineering students, but they convey different methods of curriculum design. Emerging new pedagogical approaches can also be found, such as design thinking (Chapter 14), inquiry-based learning (Chapter 6), Project-Based Learning (PtBL) (Chapter 15), and using portfolios (Chapter 11), etc. The exploration of the discussed pedagogical models in the chapters has been built on various theoretical foundations, such as psychology, cognitive, social psychology, ecology, evolution, educational philosophy, etc. All the contributions in this volume undoubtedly show that developing creative problem solving skills is in itself a complex concept to research in the context of higher education, even though it is recognized as a necessary response to the complexity in the wider context of society. In what follows, three key themes will be concluded: adaption, integration, and co-creation. This helps to unravel the thread of complexity of understanding the concept while directing the future trends of pedagogical design and research.

ADAPTION

The term ‘adaption’ has been very much discussed in relation to the adaption-innovation inventory developed by Kirton (1976, 1982, 1994). Adaptors and innovators are two creative styles, but are equally creative. The adaptors choose to do things better, while innovators choose to do things differently. Adaptors operate within a structured system associated with sufficiency of originality, efficiency, and rule-group conformity, whereas innovators break away from such an existing structured system and show great interest in originality of ideas and less concern with efficiency and rule-group conformity (Ee & Tan, 2009). Furthermore, Kirton (1994) suggested that adaptors are likely to improve on the existing structure and favor staying in groups, maintaining cohesion by following the accepted ways, and solving
Going Towards Adaption, Integration, and Co-Creation

problems in a disciplined, methodical, and predictable manner, while innovators are risk takers and are likely to generate innovative yet practical ideas, thus altering the existing paradigm (Ee & Tan, 2009).

However, both terms—‘adaption’ and ‘innovation’—have gained broader scope in recent studies than simply the earlier sense of cognitive styles. Adaption, as proposed in this chapter, is more related to discussions on complex adaptive systems (CAS). As Price (2011) described, a fashion that survives to become a professional community illustrates the property of emergent order, a phenomenon that has come in recent years to be associated with the behavior or complex adaptive, or evolving system. According to Tosey (2006), complex adaptive systems (CAS) consist of assemblies of agents that interact with one another. It was found that computer models could simulate the behavior of a natural system through quite simple rules of interaction (Waldrop, 1992). However, despite this apparent simplicity, the results of the interactions were unpredictable from knowledge of specific interactions between agents, a fundamental feature of complex adaptive systems. Such systems are also adaptive in the sense that they both respond to and proactively shape the environments or contexts in which they exist (Tosey, 2006). So CAS are dynamic systems able to adapt in and evolve with a changing environment. It is important to realize that there is no separation between a system and its environment in the idea that a system always adapts to a changing environment. Rather, the concept to be examined is that of a system closely linked with all other related systems, making up an ecosystem. Within such a context, change needs to be seen in terms of co-evolution with all other related systems, rather than as an adaptation to a separate and distinct environment (Chan, 2001). The theory of CAS is therefore useful in describing an evolutionary change process, providing insight into how the agents in a university system—students, teaching staff, curriculum designers, policy makers, managers, etc.—interact with each other and commonly contribute to adapt to a changing societal environment, while any pedagogical design for fostering creative problem solving skills provides the dynamic of interaction between those agents.

Adaption is highlighted here as one of the focuses for future research trends that show respect to the diversity of educational strategies in different cultures discussed in this volume. As no culture can balance all the needs of fostering the strongest creative learning environment, only through a self-evaluation of the personal culture, the elements that are blocking the populace, and the construction of more fertile creative soil can the agents lead the higher education to new levels of learning achievement. Adaption is a key consideration when a new pedagogical design is employed in a culture; it is also a key indicator of when to examine the strengths and weaknesses of the pedagogical design. This indicates that special attention should be paid to topics such as the responses of agents to an instruction model in relation to their creative learning experiences (e.g., Chapters 9, 11, and 13), the impact of a curriculum design on students’ creativity (e.g., Chapters 4, and 5), the interaction between creative learning and creative teaching (e.g., Chapter 22), and so on. This underpins a systematic view to developing creativity and creative problem solving in higher education (e.g., Chapters 1, 22, and 23) that requires not only the teachers facilitating students by constructing a creative learning environment (e.g., Chapters 12, and 15), but also the institutions providing a supportive environment to the teachers (e.g., Chapter 22). The spotlight on adaption is secondly inspired by the notion that differences between individuals may bring different reactions when they are given the same problem to solve or the same task to finish. This may also reflect differences between domains. The ability to adapt to a certain creative learning environment varies from person to person. Therefore the teaching strategies should allow for tolerance of diverse creative styles, use open questions, withhold criticism, and offer flexibility (e.g., Chapters 16 and 22). Meanwhile, courses teaching creative thinking skills should be designed according to the characteristics of the domain—for example, to foster creativity is quite different between engineering (e.g., chapters 5,
and 6) and the arts (e.g., Chapter 7). This further inspired a third argument for highlighting adaption as related to the concept of technology adoption, indicating the diversity among individuals’ choices to acquire and use a new technology when creative online learning is designed (e.g., Chapters 17, 18, and 19).

Apart from theories of complexity and emergence (see Chapter 1), recent work has laid the foundation for deeper exploration of the links between creative problem solving skills and adaption in higher education. For example, Price (2011) argued that organizations should develop spaces for adapting creative behaviors from a perspective of evolution. Tosey (2006) described higher education institutions as creative places which are also home to complex adaptive systems. Some creativity researchers, such as Csikszentmihalyi (1996) and Sawyer (2003), have made contributions to a historical-cultural or sociocultural view to creativity that also provides new insights into future issues on adaption.

**INTEGRATION**

By regarding creative problem solving (CPS) as a thinking model applied in organizational innovation, Puccio and Cabra (2014) suggested three future trends that might continue to shape the use of CPS, as well as the model itself. The first trend is the integration of more Eastern philosophical approaches to creativity, such as meditation and spiritual intelligence. The development of CPS has been almost exclusively driven by a Western mindset. As globalization has forced businesses to embrace more Eastern ways of thinking and behaving, so too CPS must consider how to expand beyond its cognitive, rational and semantic orientation to problem solving. That is, problem solving approaches in the future may evoke emotional, spiritual and intuitive intelligence that works in concert with cognitive intelligence to produce innovation. The second trend is the integration of technology such as software programs that parallel the stages of CPS, or the use of avatars to facilitate CPS in a multi-virtual environment. Increasingly, creative process methods are finding their way into computer programs. There are programs for mind-mapping and for visually tagging themes within a data set. The prospects appear to have important implications for how and where innovation is facilitated individually or in groups. The third trend is the integration of CPS and the methods applied in design thinking, such as ethnography. It is an inquiry into consumer activities from which information emerges that is then used to create innovation for market solutions. It would be wise for future versions of CPS to use data gathered through ethnography as a springboard to problem identification.

Although Puccio and Cabra (2014) suggested the above three trends based on a review of CPS’s history and its future in relation to organization innovation, this has been underpinned by this volume in a higher education context. As introduced previously, the volume presents a global work by collecting chapters from around 50 authors and 13 countries. Chapter 8 responds to the first trend: the integration of Eastern philosophy. It investigates creative life experiences among Chinese medical university students that consider ‘emotional intelligence’ as a key element of creativity. The results will contribute to improve students’ attitudes, confidence, open-mindedness, and creative lifestyles, etc. and to improve the creative teaching environment based on consideration of those influencing factors of emotional intelligence. Meanwhile, many authors in this volume mentioned the second trend of integration of technology (e.g., Chapters 17, 18, 19, and 20). For example, Chapter 17 figured out that pedagogical content knowledge transfer issues with the integration of Web 3.0 tools are one of the emerging areas in instruction design. While instructional design technology requires that the instruction environment is scaffolded with sufficient technology to incorporate visualization of the knowledge body, and sharing of knowledge nug-
gets and experiences while acquiring them, inclusion of communication channels speeds up learning acquisition, peer support and advice. Chapter 18 emphasized that for students in higher education, the acquisition of applicable knowledge and ICT-integrated creative problem solving skills specific to their future professions and disciplines is central to the development of their professional identities. In terms of the third trend of integration of ethnography, this has also been a research trend in creativity research in the educational context (see Chapter 1). Some chapters have made contributions to support the trend by using action research (e.g., Chapter 20), or the interview research method (e.g., Chapters 9, and 12). For example, Chapter 12 emphasized that doctoral education takes place on informal and tacit levels, where doctoral students learn about institutional regulations, the research field, academic craftsmanship, and research design by observing how their supervisors talk, act, and handle issues in the professional community. In this sense, the integration of ethnographic research methods is helpful to unpack those pockets of ‘darkness’ that are similar phenomena within doctoral education.

Apart from the three trends, another one can be concluded from this volume—that is, the integration of diversity. This involves consideration of applying diverse learning concepts, technologies, and theoretical models to pedagogical practice and diverse research methods to exploring how the pedagogical practice influences the creative learning environment. For example, Chapter 14 introduces design thinking as an educational approach to enhance creative problem solving skills. Thus a problem-based learning paradigm was developed by means of three pillars: a creative problem solving process, creative workspaces, and collaboration in multi-perspective teams. Chapter 5 developed a course of teaching creative problem solving skills in engineering education that is based on principles of active learning, problem-based learning, and a series of creativity techniques. Chapter 11 discusses how portfolios can be a powerful tool to enhance critical thinking within a course; to achieve this goal, teachers needs to consider how to apply theories such as reflective learning and constructive learning into the design of the content of portfolios. Chapter 19 suggests transformative learning and especially heutagogy, or self-determined learning, can be used as theoretical curriculum models or frameworks to help students learn and solve problems; these two theories are particularly effective when leveraged with technology. In addition, mixed research methods have been used in a few chapters (e.g., Chapters 9). All the cases listed above can also be seen as being related to the first trend of adaption: when diverse concepts, technologies and methods are merged into one educational context, adaption is the condition of designing a creative learning environment and developing it sustainably.

**CO-CREATION**

From the aspect of organization innovation, Pamaswamy and Ozcan (2014) outlined a definition of ‘co-creation: it is the joint creation and assessment of value with stakeholding individuals, intensified and enacted through platforms of engagement, virtualized and emergent from ecosystems of capabilities, and actualized and embodied in domains of experiences, expanding into wealth, welfare, and wellbeing. In order to facilitate an enterprise to change toward the co-creation paradigm, reflexivity is a key principle in building up engagement platforms. It is the movement that enables the transformation of outcomes of value and reflections on these outcomes, so it becomes a part of the assemblage system and the value it generates. This involves tools, information, insights, recommendations, meanings, lived experiences, and valuable creations from others.
By introducing the configuration of co-creation in innovation studies to higher education, co-created curriculum design highlights at least the following elements: 1) students’ active and reflective participation; 2) the changes of teachers’ role toward becoming facilitators of learning; 3) a dynamic and interactive process of teaching and learning; 4) multiple resource channels of teaching and learning; and 5) increased levels of individual and collective students’ responsibility for their learning, etc. (Bovill, 2014). Accordingly, a co-created curriculum is a basis for developing a community of practice where all learners and teachers are reflective partners who contribute to mutual engagement, a joint enterprise and a shared repertoire (Wenger, 1998). This also takes the belief that professional learning stems from continuous action and reflection on everyday problems, often involving tacit knowledge that is difficult to identify and analyze. Therefore when a professional reflects on an experience, they develop their own theoretical system. Besides learning from one’s own primary events, it is important also to consider, and value, learning from the secondary experiences of others, communicated in writing or verbally, by individuals or within groups (Pitts, 2010).

Chapter 21 particularly pointed out co-creation as one guideline for creative problem framing in higher education: opening the information and decision making processes to active participation by multiple stakeholders of the problem at hand is considered an ethical and constructive strategy. Under this paradigm, creative facilitation is particularly important in helping people reveal latent needs, implicit assumptions, and develop dialogue between stakeholders (Sanders & Stappers, 2012). Key to co-creation is learning to uncover and listen to feedback, while developing a critical eye to interpret new information and build meaning (e.g., Chapters 9, and 10). That is, reflexivity is a key principle of developing a co-creation curriculum. Reflective behavior involves the practitioner seeking insights into her practice. It accepts the subjectivity of data and interpretations, and focuses on individual insights and development. It allows individuals to define who and where they are, to take stock of their professional positions (Pitts, 2010). It drives the self-motivation that is a force causing a person to act in order to achieve a goal, and then to sustain that action until successful (Ghaye, 2010). Setting of a problem, from where the practitioner needs to identify her own strengths and weaknesses in the professional practice, often stimulates the motivation. It requires a positivity that is linked with self-regard and job satisfaction. Dialogue is another principle of enabling a co-creation experience (Pamaswamy & Ozcan, 2014). It is about shared communication and learning among equals. It entails empathic understanding built around experiencing and recognizing the emotional, social, and cultural background of experiences. It calls for a deep understanding of individual experience perspectives, which cannot be achieved without active conversation and sharing views about what is meaningful to individuals. Nurturing active dialogue is about engaging individuals on their terms and learning along with them, as everyone evolves in their needs and experiences of value. This is aligned with what Chapter 23 suggests: that higher education requires not only work under a shift of creativity research from ‘how to make people creative’ to ‘why people become creative’ and ‘when they become creative’, but also work on a paradigm shift in the mindset of the authority. This determines what students learn according to its demands. The design of education needs a significant change that has to be towards human centered design, whose prime focus is to allow one’s own self-realization, rather than a teacher-centered design whose prime purpose is to imprint a convenient model on students.
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