THE EFFECT OF AN ARGUMENTATION DIAGRAM ON
THE SELF-EVALUATION OF A CREATIVE SOLUTION

A Dissertation in
Educational Psychology

by

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ABSTRACT

Creative problem solving during which individuals generate novel and effective ideas or products is an essential 21st century skill that is most successful when learners are able to analyze, evaluate and refine their own ideas in order to improve and maximize their creative efforts (Partnership for 21st Century Skills). Engaging learners in argumentation tasks during problem solving activities has the potential to promote more reflective thinking about a proposed creative solution.

The purpose of the study was to explore creative problem solving performance and examine ways to support reflective self-evaluations of the proposed creative solutions. Undergraduate students in an introductory educational psychology class were recruited and 103 individuals completed the study online. Participants provided demographic information and completed a set of measures before they read the problem scenario. Based on the scenario they assumed the role of a high school teacher and they designed a creative college preparatory course for the high school seniors by describing the specific learning activities of the course. Depending on the experimental condition, participants completed a reflective task: either responded to an explanation prompt (Explanation condition) or completed an Argumentation Vee Diagram (Argumentation condition). Finally, participants evaluated their course by rating the course on a set of originality and effectiveness characteristics that describe creative solutions.

The findings of the study confirmed the role of divergent thinking as a positive predictor of the originality of the solution, while relevant coursework (i.e., prior knowledge) was found to be a negative predictor of originality. Moreover, need for cognition was a positive predictor of the effectiveness of a solution. Participants whose beliefs aligned with current conceptualizations of creative outcomes evaluated positively their proposed creative course. Moreover, participants who completed the argumentation diagram evaluated their course more conservatively with respect to its effectiveness indicating that an argumentation diagram is a graphic organizer that could potentially promote more reflective and critical thinking about a creative solution. Finally, an important contribution of this study is the development of a self-evaluation rating scale, which practitioners and students can use to evaluate a potentially creative outcome (i.e., product, solution).
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CHAPTER 1

Introduction

Creativity is manifested across academic domains and everyday life situations. Whether taking into consideration a mud engineer trying to find an innovative solution to stop oil leaks from an underwater well, a health and human development specialist working on designing a playground to serve the needs of a diverse community, or a group of preschool children attempting to improvise the rules of a game to accommodate more players, creativity is evident in all of these instances. Thus, creativity occurs within a context such as a particular situation, task or problem in an academic domain or everyday life context. There is some consensus among educational and psychological researchers, that creativity refers to “the ability to produce work that is novel (i.e., original, unexpected), high in quality, and appropriate in the sense that the outcome meets the constraints of a task” (Kaufman & Baer, 2004, p.4).

Creativity is the primary source of innovation and it directly impacts the sociopolitical and economic well-being of communities and countries, which move from industrialized to knowledge based-economies. Creativity is a driver for innovation and is a key factor in the development of personal, occupational, entrepreneurial and social competencies and the well-being of all individuals in a society (European Parliament and Council, 2008, §9). Innovation has become essential to address contemporary global issues such as climate change, health care reforms and sustainability (Andiliou & Murphy, 2010). Creativity also has pervasive influence on culture, economic growth, and social cohesion. Thus, many countries around the world have identified the development of creativity across subject areas as a core student learning outcome (Diakidoy & Constantinou, 2001) and have pushed for problem-based approaches that provide students with opportunities to construct creative solutions to authentic problems.

In North America there are emerging state efforts to develop a framework to examine the extent to which public schools encourage and foster creativity oriented skills such as innovation, critical thinking, and entrepreneurship based on the opportunities schools offer to students to exhibit creativity (Robelen, 2012). The States of California, Massachusetts, and Oklahoma have appointed committees or are in the process of appointing panel members who will work to generate the parameters of a creativity...
index for public schools. For example, the Massachusetts Creative Challenge Index, is essentially a creative opportunity index, which will be designed to measure the creative educational opportunities provided within a school environment that encourage the development of creativity and other important skills for the 21st century workforce (e.g., critical thinking, problem solving, collaboration, interpersonal communication). Some of the activities that the Massachusetts commission has identified as activities that promote creativity include science fairs, independent research, debate clubs, and filmmaking.

Although there is still controversy on whether a Creativity or Innovation Index will be mandatory for public schools and the purpose that the Index will serve, some teacher associations and advocacy groups welcomed the idea of a Creativity Index as part of an effort for advancing a “multiple measures” approach to evaluating schools beyond reports of standardized test scores (Robelen, 2012). These efforts undertaken by some states echo the importance of developing the students’ capacity to create and innovate in order to improve the nation’s competitiveness in an era of knowledge-based societies.

A growing interest in creativity, its nature, and the variables that contribute to its manifestation is also evident among educational and psychological researchers. During the last century researchers studied creativity using different lenses including psychodynamic, psychometric, cognitive, and confluence approaches. The proponents of the psychodynamic approach (e.g., Freud) examined case studies of eminent creators such as Michelangelo and Einstein to determine how creativity arises from the tension between conscious reality and unconscious drives (Sternberg & Lubart, 1999). Researchers who studied creativity from a psychometric perspective administered paper-and-pencil tests to measure creativity. An example of a psychometric assessment is the Torrance Test of Creative Thinking (TTCT, 1974) which consists of verbal and figural tasks. The TTCT assesses abilities such as fluency, originality, flexibility, elaboration, and resistance to premature closure. However, the tasks included in such psychometric tests have been criticized for being unauthentic and decontextualized from any knowledge domain.

Cognitive scientists explored the cognitive processes underlying creative thinking (Smith, Ward, & Finke, 1995; Weisberg, 1999; 2006). The research of cognitive scientists revealed that processes such
as association, synthesis, and analogical transfer contribute to creative thinking. In addition to these general reasoning skills, cognitive scientists pointed to the significance of domain knowledge in creativity (Weisberg, 1999). However, cognitive variables are not sufficient to explain creativity. Creativity is a complex phenomenon and in order to construct a more coherent understanding of this psychological phenomenon some researchers explored the interplay of cognitive, affective, personality and social variables that converge for creativity to occur. The most often cited confluence approaches include Amabile’s (1983) componential model of creativity and Csikszentmihalyi’s (1996) systems view of creativity.

The componential model of creativity postulates that creativity is the confluence of domain relevant knowledge and skills, intrinsic and extrinsic task motivation, and general creativity relevant processes such as cognitive style and divergent thinking. These contributing factors identified in Amabile’s componential model represent intra-individual variables that contribute to creativity. Csikszentmihalyi’s systems framework is another confluence approach that positions the individual in a social context and explains how the individual, domain, and field interact. An individual transforms or extends domain knowledge via cognitive processes and personality characteristics, driven by the motivation to create something new (Csikszentmihalyi, 1999). Influential individuals in the field evaluate and select new ideas based on some consensus about the contribution of an idea in the field. Finally, the domain, which is a culturally defined system, presents and communicates creative outcomes to other individuals and future generations (Sternberg & Lubart, 1999). Comprehensive approaches to the study of creativity have contributed to mapping the spectrum of intra- and extra-individual variables that contribute to creativity. There is still more to explore regarding the way cognitive, metacognitive, affective, personality, and social variables interact and give rise to different creative achievements.

**Creative Problem Solving**

Creativity is typically manifested in response to ill-structured problems that require original and effective solutions. Ill-structured problems are complex problems in which any one of the three components, namely the initial state, the goal state, and/or the allowable operators are not clearly
specified (e.g., Voss & Means, 1989). It is under these ill-structured conditions that individuals engage in creative problem solving, which is a goal directed cognitive process that results in the production of original and effective solutions when no obvious solution method is available.

Creative problem solving evolves across several cognitive subprocesses initiated by the construction of a problem space, the generation of ideas, the evaluation of a selected solution, and potentially its implementation. Variables including individual differences such as divergent thinking, analogical reasoning, the ability to monitor cognition, and the need for cognition, play a role in developing creative solutions.

Domain specific expertise is another contributing factor to creative performance and differentiates the performance of experts and novices in problem solving. Experts have more integrated domain knowledge that helps them represent a problem in a more coherent way and they are more strategic as they apply domain specific strategies that were successful in the past. Experts are better critical thinkers as they spend more time in evaluating a solution, they can anticipate potential problems with the solution and if necessary they construct another representation and attempt to solve the problem again (Voss, Greene, Post & Penner, 1983). Among the critical thinking processes the evaluation of a solution has been identified as especially challenging for novices.

Evaluation is a metacognitive process in which problem solvers reflect and assess a selected solution. When problem-solvers evaluate a solution, they forecast the expected potential outcomes (i.e., negative and positive consequences) stemming from the implementation of a solution and judge the solution based on a set of standards. The evaluation of a solution can result in the rejection of the solution, its implementation as is, or its revision (Mumford, Lonergan, & Scott, 2002). Evaluation is essential for ill-structured problems that require a creative solution because it is the means by which problem solvers can determine whether their proposed solution is both original and effective.

Problem solving researchers have recognized the importance of supporting novices in developing the metacognitive ability of evaluation so that they become able to reason analytically and critically about their solutions, refine their solutions, and be able to successfully present and implement them (Hernandez-
Researchers explored interventions designed to scaffold learners’ problem solving process by providing prompts, directions, exemplar cases, visual aids, collaborative problem solving opportunities, and verbal and pictorial argumentation scaffolds (e.g., diagrams) (Chen & Bradshaw, 2007; Cho & Jonassen, 2002; Choi & Lee, 2009; Marttunen & Laurinen, 2006). Expanding this line of research, the present study aims to examine the effect of an argumentation diagram on the evaluation of a creative solution proposed to an ill-structured course design problem.

**Statement of the Problem**

Students are regularly challenged when they are asked to submit creative assignments or provide creative solutions to problems and they are often overwhelmed by this challenge. One reason that might explain learners’ negative reactions when faced with problems that require creative solutions is that they are unsure about the characteristics of creative outcomes and consequently uncertain about how to judge whether a solution they have generated is a creative one. Moreover, researchers have found that often students’ thinking about and evaluation of a self-generated solution is superficial rather than reflective (Runco & Smith, 1992; Runco & Chand, 1994). Students tend to engage in case-building about a solution. Instead of critically judging the solutions they exhibit what researchers have referred to as my-side bias (or minimization) in which individuals argue about and justify their solutions by discounting potential obstacles and consequences or curtailing the importance or extensiveness of a problem (Dailey & Mumford, 2006; Byrne, Shipman, Mumford, 2010; Nussbaum, 2008).

Researchers have used structure supports such as prompts, directions, visual representations, collaborative problem solving, and argumentation scaffolds to support students’ reasoning during problem solving. One of the assumptions undergirding these interventions is that structure supports, which involve students in thinking about other perspectives, opinions, and approaches to the problem can promote critical thinking and improve performance (Chen & Bradshaw, 2007; Ge & Land, 2003). Embedding and fostering argumentative activities in learning environments were found to promote productive ways of thinking, and facilitate conceptual change and problem solving (Nussbaum & Sinatra, 2003; Nussbaum, Winsor, Aqui, & Polyquin, 2007; Voss & Means, 1991; Wiley & Voss, 1999).
Argumentation scaffolds represent a type of structure support that has the potential to facilitate reflective evaluation of a solution. As Jonassen and Kim (2009, p. 439) proposed, argumentation is the means by which we rationally resolve questions, issues, and disputes and solve problems. Argumentation scaffolds including collaborative problem solving, online computer supported problem solving, and argumentation diagrams significantly improved students’ argumentation skills and group problem solving with some marginal effects on individual problem solving performance (Cho & Jonassen, 2002; Oh, & Jonassen, 2007; Uribe, Klein, & Sullivan, 2003). However, past research has not specified how argumentation scaffolds and specifically argumentation diagrams influence the quality of metacognitive processes in problem solving such as the evaluation of a solution and the extent to which students’ reasoning about a solution can become more reflective and less biased. The present study intends to address this gap in the literature by examining the effects of an argumentation diagram on the self-evaluation of a creative solution that participants forwarded to a course design problem.

An Argumentation Vee Diagram is a type of argumentation scaffold developed by Nussbaum (2008) to serve as a graphic organizer (i.e., prewriting tool) to support reflective thinking for opinion essays. The argumentation diagram was designed to help writers generate arguments and counterarguments, and evaluate and integrate both sides of an issue by using integration strategies such as weighing the advantages and disadvantages of opposing views and synthesizing opposing views to develop a final conclusion on a controversial question (see Figure 1.1).

In problems that require a creative solution - both original and effective, it is essential for the problem solver to be able to not only present and explain a solution but to think critically about potential objections or challenges people may have against a proposed creative solution.
Figure 1.1. The Argumentation Vee Diagram as developed by Nussbaum (2008)

An Argumentation Vee Diagram has the potential to promote reflective and critical thinking when students self-evaluate a potentially creative solution. Students can use an Argumentation Vee Diagram to generate reasons that support their solution and to anticipate potential objections that others may put forward, weigh their relative strengths and even synthesize these views. This empirical study examines the comparative effect of an Argumentation Vee Diagram and an explanation prompt on students’ evaluation of a proposed creative solution to a course design problem.

Purpose of the Study

Creative problem solving is a complex cognitive process that relies on various cognitive and affective factors. The purpose of the study was to explore creative problem solving performance and examine ways to support reflective self-evaluations of the proposed creative solutions. Firstly, the study explores the content of the creative solutions and investigates the degree to which individual difference variables including divergent thinking, need for cognition, beliefs about creative outcomes, and curriculum and instructional design coursework predict the creativity of a solution. Secondly, this empirical study examines the comparative effect of an argumentation diagram and an explanation prompt on the self-evaluation of the creative solution by the problem solver.
Research Questions

Four research questions guided this study:

1. What is the content of creative solutions proposed to a course design problem?
2. How do students conceptualize creative outcomes?
3. How do individual differences in divergent thinking, need for cognition, relevant coursework in curriculum and instructional design, and beliefs about creative outcomes impact the creativity of a solution with respect to its (a) originality and (b) effectiveness?
4. To what extent does an argumentation diagram support the self-evaluation of a solution?

Research Question 1: The problem-solving task that participants had to complete required them to assume the role of a newly hired high school teacher who was asked by the principal to design a creative high school course to prepare a high school seniors’ for the transition to college. Participants were expected to identify the overall purpose of the course and propose specific learning activities for their course. The first research question explores the type of learning activities and other task relevant responses that participants proposed for their creative high school course.

Research Question 2: The second research question is also exploratory and intends to examine how undergraduate students conceptualize creative solutions. Undergraduate students are often directed to generate creative solutions to classroom assignments. However, frequently students are left pondering and wondering about the characteristics of creative outcomes. Moreover, few undergraduate students have in-depth knowledge of the literature on creativity and problem solving and in the absence of classroom discourse about creativity, it is expected that most students have narrow conceptualizations of creative solutions that focus on the originality of a solution.

Hypothesis 2.1. The majority of the students will rate higher the characteristics of a creative outcome that pertain to its originality than its effectiveness.

Research Question 3. A number of individual difference variables are expected to impact the creativity of a solution with respect to its originality and effectiveness. Individual difference variables including divergent thinking and need for cognition have been identified in the empirical literature on
creative and ill-structured problem solving as predictive of problem-solving performance. Divergent thinking is defined as the ability to generate various ideas and it was found to predict performance on creative problem solving (e.g., Hunter et al., 2008; Osburn & Mumford, 2006; Reiter-Palmon et al., 2009; 1997). Besides divergent thinking, one’s need for cognition was also documented to be predictive of creative problem solving performance (Butler, A.et al., 2003; Hunter et al., 2008; Osburn & Mumford, 2006).

Hypothesis 3.1. Students who are good divergent thinkers and are high in need for cognition will propose original and effective solutions.

Students’ conceptualizations of creative solutions could also potentially impact the creativity of a proposed solution. Past research has suggested that problem solvers’ perceptions of a task and their domain knowledge impacts how individuals represent a problem and the way they assess the viability of potential solutions (Jonassen, 1997; Voss et al., 1991). Drawing on these findings, students whose conceptualizations of creative solutions align better with existing definitions of creative outcomes as both original and effective are more likely to generate solutions that meet both characteristics.

Hypothesis 3.2. Students who conceptualize creative solutions as both original and effective will develop a solution that is highly effective and may or may not be original.

Finally, there is evidence to suggest that prior knowledge is a variable that plays a role in creative problem solving performance. Knowledge of the important concepts and principles in a domain contributes in a more effective search for relevant information, more comprehensive representation of the problem, and better performance on ill-structured tasks (Devine & Kozlowski, 1995; Shin, Jonassen, & McGee, 2003; Voss & Post, 1988). Furthermore, domain knowledge serves as the foundation for the development of creative solutions (Weisberg, 2006).

Hypothesis 3.3. Students who possess more extensive prior knowledge acquired through college courses relevant to curriculum and instructional design will propose highly effective solutions.

Research Question 4. A few studies have documented that argumentation skills predict performance in group-based and individual ill-structured problem solving (Kapur & Kinzer, 2009; Shin et
Moreover, Voss and her colleagues (1981) argued that argumentation is a means for problem solvers to evaluate a solution, identify potential drawbacks and elaborate or clarify aspects of the solution. Specifically, a type of graphic organizer, the Argumentation Vee Diagram, was found to promote integration of arguments and counterarguments in students’ reflective thinking. In this study, the use of an Argumentation Vee Diagram in which students generate and integrate reasons and objections to a solution to a course design problem, is expected to promote more reflective thinking and critical evaluation of the potentially creative solution.

**Hypothesis 4.1.** For students who complete an Argumentation Vee Diagram, the effectiveness of their proposed creative solution will be strongly and positively predictive of the self-evaluation of the solution with respect to its effectiveness.

**Hypothesis 4.2.** For students who respond to an Explanation prompt the effectiveness of their solution will be less predictive of the self-evaluation of the solution effectiveness.
**Definition of Key Terms**

**Analogical Reasoning** refers to a form of inductive reasoning in which one draws an analogy between a familiar analog termed a source or base and a target which is an unfamiliar situation. “Two situations are analogous, if they share a common pattern of relationships among their constituent elements, when the elements differ across the two situations” (Holyoak, 2004, p. 117).

**Argumentation Skills** include “formulating and weighing the arguments for and against a course of action, a point of view, or a solution to a problem” (Kuhn, 1991, p. 2). There are five component skills of argumentation including (a) generating causal theories to support claims, (b) offering evidence in support of theories, (c) generating alternative theories, (d) envisioning conditions that would undermine the theories they hold, and (e) rebutting alternative theories (Kuhn, 1991).

**Beliefs** include “…all that one accepts as or wants to be true. Beliefs do not require verification and often cannot be verified (e.g., opinions)” (Murphy & Mason, 2006, p. 310).

**Creativity** refers to “the ability to produce work that is novel (i.e., original, unexpected), high in quality, and appropriate in the sense that the work meets the constraints of a task” (Kaufman & Baer, 2004, p.4).

**Creative Problem Solving** represents a goal directed cognitive process that results in the production of original and effective solutions when no obvious solution method is available.

**Divergent Thinking** refers to “the ability to generate a large number (fluency) of different ideas (flexibility) that are unusual (originality) and richly detailed (elaboration)” (Diakidoy & Constantinou, 2001).

**Domain Knowledge** refers to a type of conceptual knowledge that represents a realm of knowledge that broadly encompasses a field of study or thought (Alexander, Shallert, & Hare, 1991).

**Ideational Fluency** refers to the production of ideas appropriate in meaning in response to a given idea (Merrifield, Guildford, Christensen, & Frick, 1962).

**Ill-Structured Problem** is a problem in which any one of the three components (initial state, operators, goal state) is not well specified (Chi & Glaser, 1985).
Learning Activity includes any learning experience either enactive (i.e., through actual doing) or vicarious (i.e., students observe, listen or engaged in other ways) designed for the learners to attain an instructional goal such as the acquisition of information, knowledge, skills, abilities, attitudes and strategies.

Means-Ends Analysis is a problem-solving strategy in which “one compares the current situation with the goal to identify the differences between them, sets a subgoal to reduce any of the differences, performs operations to reach the subgoal, and repeats the process until the goal is attained (working forward)”. One can work backward from the goal to the initial state by planning a series of moves each designed to attain a subgoal (Schunk, 2004, p. 484).

Need for Cognition refers to “an individual’s tendency to engage in and enjoy effortful cognitive endeavors” (Cacioppo, Petty, & Kao, 1984, p.306).

Prompts include statements or questions used to guide and scaffold the learning process offering both cognitive and metacognitive support to students and they usually appear in the form of procedural, elaboration or reflection prompts (Ge & Land, 2003).

Structure Supports include any kind of support or scaffold temporarily provided to problem solvers to support them while they are engaged in solving a particular problem in order to reduce the degrees of freedom in a problem (Kapur, 2009). Examples of structure supports include question prompts, computer supported argumentation tools, visual aids such as concept maps, diagrams, and tables.

Solution Evaluation is the cognitive process of forecasting the outcomes of implementing a solution idea and appraising the solution based on a set of standards taking into consideration the setting(s) in which the idea is to be implemented (Mumford, Lonergan, & Scott, 2002).
CHAPTER 2
Review of Literature

The purpose of this review of literature is to develop a theoretical framework for the study of the effects of argumentation scaffolds on creative problem solving and specifically the self-evaluation of a proposed creative solution by undergraduate students. In the cognitive and educational psychology literature of the last century, one prominent conceptualization of creativity portrays it as a form of problem solving (Lubart, 2000). Several creativity researchers argued that creativity manifests itself in problem solving tasks that are ill-structured (Diakidoy & Constantinou, 2001; Mumford, Mobley, Uhlman, Reiter-Palmon, Doares, 1991). In order to theoretically position this study, the first section analyzes and critiques the extant models of ill-structured problem solving (ISPS) and creative problem solving (CPS) to determine whether the additional originality requirement imposed in CPS tasks, differentiates the problem solving process from ISPS.

In the second section, I examine and compare the variables (e.g., cognitive, metacognitive, and affective), which predict or are associated with ISPS and CPS in order to explore whether different variables contribute to solving problems which require original and effective solutions. Solving ill-structured problems is challenging, and researchers have provided three major types of structure supports for problem solving namely prompts, cases, and scaffolds both verbal and nonverbal. Section three discusses the effectiveness of structure supports on ISPS with a focus on argumentation scaffolds and the degree to which they improve the quality of argumentation and performance in complex problem solving tasks. Recommendations for practitioners and scholars who aim to promote creative problem solving are forwarded in the final section of the literature review.

Ill-Structured Problem Solving

Problems vary in their degree of structuredness, complexity, and domain specificity (Jonassen, 1997). For problems described as ill-structured, one of the three component(s)-namely the initial state, the goal state, and/or the allowable operators-are not clearly specified (Voss & Means, 1989). Ill-structured problems are often complex because the problem solver has to define the goals of the activity
and make decisions about the concepts, rules, and principles needed for the solution, the strategies to solve the problem, the criteria for evaluating the solution, and the justification of the solution. Three models of ISPS have been forwarded to describe the cognitive processing when dealing with this class of problems. Table 2.1 provides a summary of the cognitive processes of the three models of ISPS followed by a discussion of the models.

Table 2.1

<table>
<thead>
<tr>
<th>Models of Ill-Structured Problem Solving</th>
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<tbody>
<tr>
<td>Sinott (1989)</td>
</tr>
<tr>
<td>Voss et al. (1983)</td>
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<tr>
<td>Jonassen (1997)</td>
</tr>
<tr>
<td>Construct problem space(s)</td>
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<tr>
<td>Problem solving control</td>
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<tr>
<td>Articulate problem space</td>
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<tr>
<td>Generate and select solution</td>
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<tr>
<td>Create problem space</td>
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<tr>
<td>Identify alternative perspectives</td>
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<tr>
<td>Monitoring</td>
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<tr>
<td>Identify subproblem(s)</td>
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<tr>
<td>Generate possible problem solutions</td>
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<tr>
<td>State Solution</td>
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<tr>
<td>Assess the validity of alternative</td>
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<tr>
<td>solution options</td>
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<tr>
<td>Evaluate solution</td>
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<tr>
<td>Monitor the problem space and the</td>
</tr>
<tr>
<td>solution options</td>
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<tr>
<td>Reasoning</td>
</tr>
<tr>
<td>Monitor the problem space and the</td>
</tr>
<tr>
<td>Monitor the solution</td>
</tr>
<tr>
<td>Argumentation</td>
</tr>
<tr>
<td>Implement and monitor the solution</td>
</tr>
<tr>
<td>Adapt the solution</td>
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</table>

Model for solution of ill-structured problems. Sinnott (1989) developed this model for ill-structured problem solving by researching everyday problem solving. Sinnott’s model includes (a) processes to construct problem spaces based on the perceived goal of the problem and the solver’s belief systems (i.e., epistemic cognition) and (b) processes through which a problem solver generates and chooses solutions (e.g., select a goal suitable to the perceived essence of the problem, select a reachable goal, and use an available heuristic). Monitoring is essential throughout problem solving to control the flow of the process, the shifts between problem spaces, the choice of a problem solution and the regulation of emotional reactions. Finally, Sinnott (1989) found that episodic memories of personal history events were found to be important in solving everyday ill-structured problems.

Problem solving-reasoning model. Voss and her colleagues developed this model by researching problem solving in social sciences and international relations (Voss, Greene, Post, & Penner, 1983). The problem solving-reasoning model contains two cognitive structures: the problem solving
control structure (G) and the reasoning structure (R). The problem solving control or goal structure monitors the problem solving process. It consists of operators that act upon one’s knowledge base to generate a solution. The “hard core” operators include stating a constraint, stating a subproblem, and stating the solution either to the given problem or to a subproblem (Voss et al., 1983, p. 171). There are two general problem solving mechanisms for representing a problem: (a) decomposition of the problem to elements which are the primary causes of the problem, and (b) conversion to a solvable problem.

In addition to the “hard core” operators, the goal structure has also supportive operators (i.e., interpret the problem statement, provide support, evaluate, summarize), which are used in conjunction with the reasoning structure operators. The application of the reasoning operators begins by stating an argument. Other reasoning operators include stating assertions and facts, presenting exemplar cases, stating reasons and outcomes, comparing, contrasting, elaborating, clarifying and explicating conclusions and qualifiers. Voss and her colleagues observed that the reasoning structure is domain related as the problem solvers drew on their domain knowledge to develop their reasoning.

**Design theory of problem solving.** Jonassen (1997) developed a 7 step ISPS model based on his research of problem solving in the domain of instructional design. Initially one articulates the problem space and any constraints based on the context of the problem. Then the problem solver identifies and clarifies alternative opinions, positions, and perceptions of the stakeholders involved in the problem situation. In the third step, based on the problem solver’s perception of the constraints and the causes of the problem, s/he generates potential solutions. To select a solution, the problem solver assesses the validity of alternative solutions by constructing arguments.

Throughout the first four steps, epistemic monitoring (Jonassen identified this as the fifth “step”) guides the problem solver’s effort to represent the problem and select a solution. An individual draws on his/her epistemic beliefs about what it means to know and when one comes to know, the sources of knowledge, the kind of justification required for public verifiability, and the limits of knowledge. In step six, the problem solver implements and monitors the solution to determine its effectiveness and its utility.
for solving other similar problems. Finally, if the problem solver is able to implement the solution it is possible to modify and adapt the solution based on self-evaluation or feedback.

A Comparison of the Ill-structured Problem Solving Models

The three models of ISPS bear similarities with respect to the main component cognitive processes of problem solving. All three include the processes of constructing a mental representation of the situation (i.e. problem space), generating a solution(s), and monitoring problem solving. Another common aspect of all models of ISPS is the central role of metacognitive monitoring in ISPS, which is evident not only in the control of the flow of the process but also in the construction of a problem space and the selection of a solution. Finally, in all models the problem solver’s task perceptions, beliefs, and epistemic cognition inform metacognitive monitoring.

Even if the models share some core process components there are subtle differences between the three models with respect to the solution generation process. For example, in Sinott’s (1989) and Jonassen’s (1997) models, the problem solver constructs multiple problem spaces, shifts across them and decides which space to use more fully or develops a new problem representation by establishing associations among the problem spaces. However, Voss and colleagues’ (1991) research using international relation problems indicates that an alternative solution is considered when the constraints of a problem are not satisfied, in which case the problem solver re-represents the problem to develop another solution.

Solution evaluation is a metacognitive component that is presented as an element of ISPS by Voss et al. (1983) and Jonassen (1997). In both models the problem solver evaluates the solution by developing an argument. As Voss and her colleagues (1983) argued evaluation of a solution “is a jurisprudence process in that a person builds a case for a particular solution (p.211)”. Solution evaluation according to Voss et al. (1983) occurs either by evaluating the solution in relation to a problem constraint, or by justifying a solution by examining its implications in terms of what it could accomplish. In the case of multiple alternative solutions, Jonassen (1997, p.81) suggests that the problem solver assesses the viability of alternative solutions either by arguing for the preferred solution or against alternative
solutions. Thus, argumentation has a central role in the evaluation of solution(s) both in the Problem solving – Reasoning model and in the Design Theory of Problem Solving (1997) as it provides the structure and the means for evaluating a solution.

Ill-structured problems allow greater “discretion and creativity” in how to go about solving them because not all the parameters are specified and the problem solver defines these parameters (Greeno, Korpi, Jackson, & Michalchik, 1990 p. 1). As noted before, several creativity researchers have argued that creativity is a problem solving process manifested in response to ill-structured tasks, and they have proposed models to explain the creative problem solving process (Mumford, Supinsk, Baughman, Costanza, & Threlfall, 1997; Ward, et al., 1999; Weisberg, 1999). In the next section I present the four most prominent models of CPS and I compare them with the three models of ISPS discussed previously to determine whether the originality requirement differentiates the paradigms.

**Creative Problem Solving**

Creative problem solving is a goal directed cognitive process that results in the production of original and effective solutions when no obvious solution method is available. Several models were proposed to describe the creative problem solving process. Below I summarize (see Table 2.2) and discuss the four most prominent models that conceptualize creativity as a problem solving process.

**Table 2.2**

*Models of Creative Problem Solving*

<table>
<thead>
<tr>
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<tbody>
<tr>
<td><strong>Preparation</strong></td>
<td>Understanding the problem</td>
<td>Problem Generating</td>
<td>Problem construction</td>
</tr>
<tr>
<td>Incubation</td>
<td>Mess-finding</td>
<td>Problem-finding</td>
<td>Information encoding</td>
</tr>
<tr>
<td>Illumination</td>
<td>Data-finding</td>
<td>Fact-finding</td>
<td>Category selection</td>
</tr>
<tr>
<td>Verification</td>
<td>Problem-finding</td>
<td>Problem Formulating</td>
<td>Conceptual combination</td>
</tr>
<tr>
<td>Generating ideas</td>
<td>Generating ideas</td>
<td>Problem definition</td>
<td>Idea generation</td>
</tr>
<tr>
<td>Idea-finding</td>
<td>Problem Solving</td>
<td>Idea-finding</td>
<td>Idea evaluation</td>
</tr>
<tr>
<td>Solution-finding</td>
<td>Evaluate and select</td>
<td>Plan</td>
<td>Implementation planning</td>
</tr>
<tr>
<td>Planning for action</td>
<td>Plan</td>
<td>Solution monitoring</td>
<td></td>
</tr>
<tr>
<td>Acceptance-Finding</td>
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</tbody>
</table>

*Note. Among the above models all except Basadur et al.’s (2000) allow recursive thinking*
Wallas’s model of the creative process. The first model of the creative process was developed by Wallas (1926) who defined the creative process as the sequence of thoughts and actions that leads to a novel and adaptive product. Wallas argued that creative problem solving involves four processes: 1) preparation, 2) incubation, 3) illumination, and 4) verification. During the preparation stage the problem solver defines and analyzes the problem and at the stage of incubation, the individual unconsciously forms associations or idea combinations of which some are rejected but others are unconsciously selected. Illumination begins with the occurrence of the “aha moment” when a potentially fruitful idea arises at the conscious level. Finally, the verification stage is a conscious stage during which ideas are evaluated, refined and developed (Lubart, 2000).

Wallas (1926) explained that the stages are not strictly consecutive but could be recursive and as a case in point he offered the example of identifying problems in an idea during the idea verification stage and having to incubate to resolve them. Researchers have challenged the discreteness of the processes as it was found that it is possible for processes to occur concurrently (Lubart, 2000).

The creative problem solving framework. This model originates from the work of Alex Osborn (1953) who was invested in promoting creativity in individuals and groups in order to support their ability to find new and useful solutions. Isaksen and Treffinger (1985) expanded and refined the initial conceptualization of this model. For these researchers a problem can be “any important, open-ended, and ambiguous situation for which one wants and needs new options and a plan for carrying out successfully a solution” (p.304).

According to Isaksen and Treffinger (1985) creative problem solving has six “stages” organized into the three components of understanding the problem, generating solution ideas, and planning for action by preparing and developing solutions for effective implementation. The six stages fall under these three components of creative problem solving and these are: mess-finding, data-finding, problem-finding, idea-finding, solution-finding, and acceptance-finding. Figure 2.1 is a graphic representation of the CPS framework.
Figure 2.1. The creative problem solving components (Isaksen, Dorval, & Treffinger, 1994).

Understanding the problem encompasses stating a general, broad goal or a direction for problem solving (mess-finding), identifying important data and relevant facts (data-finding), and specifying a question to focus subsequent problem solving (problem-finding). Once the problem statement becomes available, the problem solver engages in idea generation during which s/he generates options, reviews and selects promising alternatives (idea-finding). After several potential fruitful ideas are identified, the problem solver plans for further action by closely evaluating the promising options to refine them (solution-finding). Finally, the problem solver specifies potential sources of assistance and resistance for the possible solutions. These could be any individuals, places, materials, and things that can either support or hinder further planning actions and implementation of a potential solution (acceptance-finding).

The CPS framework is not a simple, step-by-step model in which the problem solver runs through the six stages rather the CPS framework “provides a structured set of operations or tools as resources upon which the problem solver draws as needed” (Treffinger, 1995, p.305). Thus, the problem solving process is flexible and dynamic and is based on a task appraisal in which the problem solver “deliberately assesses the intended outcomes, the people, the situation, the methods available, and the techniques to be used” (p.305).
**The Simplex creative model.** The basic premise is that two mini processes namely ideation and evaluation occur in the three phases of creative thinking. According to Basadur, Runco, and Vega (2000) individual, team, and organizational creativity is a continuous, dynamic, circular 3-phase process of finding problems, solving them and implementing successfully new solutions that can potentially lead to the discovery of additional novel and useful problems.

Ideation and evaluation occur within each of the three phases of the Simplex creative model. Ideation or active divergence is defined as “the generation of alternative ideas without evaluation” (Basadur et al., 2000, p.80). On the other hand, evaluation, or active convergence is defined as the process of judging the generated ideas to select the most significant options. Idea generation is complemented by idea evaluation, a two-step procedure during which ideas are evaluated for their relevance and appropriateness and their degree of originality (Runco & Chand, 1994).

As seen in Figure 2.2., four stages comprise the Simplex creative model: problem generation, problem formulation, problem solving, and solution implementation.

*Figure 2.2. The Simplex Model of Creative Process.*

The eight subprocesses under the four stages of the Simplex model are very similar to the six stages described in the Creative Problem Solving Framework. For example, problem and fact-finding in the Simplex model correspond to the mess-finding and data-finding in the CPS framework; and idea-
finding and evaluate, select and plan in the Simplex model correspond to idea-finding and solution-finding in the CPS framework. The nuance in the Simplex model lies in the cycles of ideation and evaluation that occur in different phases of problem solving, although one could argue that they are evident as divergent and convergent thinking in the CPS framework.

**Mumford et al.’s (1991) model of the creative process.** A model of the cognitive processes involved in creative problem solving was proposed by Mumford, Mobley, Uhlman, Reiter-Palmon, and Doares (1991). The creative process model permits recursive processing between the eight core processes involved in creative thinking: 1) problem construction, 2) information encoding, 3) category selection, 4) conceptual combination, 5) idea generation, 6) idea evaluation, 7) implementation planning, and 8) solution monitoring (Blair & Mumford, 2007).

![Figure 2.3](image.png)

**Figure 2.3.** Mumford et al. (1991) model of creative thought.

In Mumford et al.’s (1991) model of creative thought, creative problem solving begins when an individual encounters a novel, ill-structured situation and attempts to define the problem at hand. In order to construct the problem, learners may need to search through multiple problem representations and use a
number of them to understand the problem and identify goals, procedures, information and constraints 
(Reiter-Palmon, Mumford, O’ Connor Boes, & Runco, 1997). The new problem representation that 
emerges from combining and reorganizing the above elements guides the search for relevant information, 
and the individual eventually identifies and selects categories or concepts that can be applied in the 
specified situation. The categories are combined and reorganized to produce new ideas (understandings 
of the problem), which are then evaluated. Based on the idea evaluation process, an idea or a set of ideas 
are implemented and the effectiveness of idea implementation is monitored (Mumford, Baughman, & 
Sager, 2003).

A Comparison of the Creative Problem Solving Models

The models presented above to describe the creative problem solving process have several 
common cognitive components. The process is initiated with problem construction which includes 
identifying the existence of a problem and defining an ambiguous situation into a workable problem by 
developing a mental representation of the situation. The problem construction stage precedes the idea 
generation stage in CPS models in which the problem solver produces multiple solution ideas. Idea 
generation is an integral part of the CPS models. However, in Wallas’ (1926) and Mumford et al.’s 
(1991) models there is an intermediate cognitive process in which ideas are associated and integrated 
before the problem solver generates solution idea(s). Such conceptual combination gives “rise to new 
concepts which provide a basis for subsequent idea generation” (Mumford, Blair, & Marcy, 2006, p. 118). 
In all models but Wallas’s the problem solver generates alternative solution ideas and selects an idea by 
applying a set of evaluation standards. In Wallas’s model the problem solver experiences an illuminative 
distinct “aha moment” in which s/he is struck by an insight resulting in the creative solution.

Idea evaluation is a common metacognitive component of CPS models as they all share a 
component that allows the evaluation of the most promising and potentially fruitful solution idea. Idea 
evaluation in models of CPS involves the appraisal of the formulated idea based on a set of standards that 
influence the acceptance and successful implementation of the idea within a setting, domain, or field 
(Csikszentmihalyi, 1999). Idea evaluation as conceptualized in a model proposed by Mumford, Lonergan
and Scott (2002) consists of three subprocesses: (a) forecasting the outcomes of idea implementation; (b) appraising the solution idea with respect to a set of standards, and (c) revising ideas based on the task requirements and the implementation context (Lonergan et al., 2004).

Idea evaluation begins with forecasting the potential outcomes and the consequences of implementing an idea within a specific context. Forecasting relies on the perceived task requirements, the goals of problem solving, and the set of standards that the problem solver establishes in order to judge the solution. Appraisal of the solution is based on a set of standards, and the process of appraising the solution informs decision making on whether the idea should be implemented as it is, revised or abandoned. Eventually the problem solver may revise the solution based on the standards and the implementation context before the idea gets implemented. In some instances, the problem solver generates new ideas if forecasting suggests that problems are expected to arise when the solution is implemented or if the appraisal is not satisfactory.

Despite the fact that all the models present evaluation as a cognitive operation that comes post-idea generation to evaluate the chosen solution, some form of evaluative thinking occurs while the solution is formulated. Empirical support was found in a study conducted by Lubart (cited in Lubart, 2000) who prompted participants to evaluate their work as they composed short stories and made still life drawings. The researcher had systematically manipulated the timing of the evaluations, the number of the evaluations and the evaluation prompt. The results showed that for the writing task, the timing of self-evaluation had a significant effect on the creativity of the outcome. The participants who evaluated their ideas earlier in the process had higher average creativity score than those who evaluated their work later or who were prompted to evaluate throughout the task. Further research is needed to determine whether evaluative thinking has a more prominent cognitive monitoring role during CPS rather than only being a closure process for judging a solution.

Other metacognitive processes in the CPS models besides solution evaluation include planning and solution monitoring. Traditionally, planning is defined as the process by which the problem solver decides which method to devise to solve the problem (Mayer & Wittrock, 2006) and it is described as
process planning in Isaksen and Treffinger’s CPS framework (1994). Moreover, monitoring the implementation of a solution is another metacognitive aspect associated with the application rather than the generation of a creative solution and it closes the loop of the CPS process in the model proposed by Mumford et al. (1991).

In summary, problem construction, idea generation and idea evaluation are the integral cognitive components of creative problem solving models. In the section that follows, I will discuss the degree to which ISPS and CPS present two distinct forms of problem solving by comparing (a) the goals of each problem solving activity and (b) the cognitive components of the two processes.

**Looking Beyond the Problem Solving Paradigms**

The primary goal in creative problem solving is to develop solutions that are original and effective so that they address the goals and comply with the constraints of a problem situation. The models of creative problem solving aim to provide an explanation of the process that leads to develop effective and original solutions. However, to what extent does the requirement for novelty that characterizes creative problem solving differentiates this cognitive process from ill-structured problem solving?

Two components of creative problem solving have been proposed by creativity researchers to be unique descriptors of the creative problem solving process. First, researchers argue that creative problem solving is a distinct form of problem solving because in CPS, problem construction is based on multiple activated representations (Mumford et al., 1991). In fact, the problem solver moves across alternative representations of the problem and searches these multiple activated problem spaces in order to identify the goals, key information, procedures to solve the problem and the relevant constraints that will form a new problem representation. Second, creativity researchers propose that creative problem solving is a distinct form of problem solving due to the process by which ideas are integrated. Association of concepts permits the generation of several ideas from which a creative solution emerges (Weisberg, 2006).
Despite the fact that creativity researchers argue that the nature of problem construction, conceptual combination and idea generation in CPS differentiate it from ISPS, these processes are very similar to those in ISPS models. Searching through multiple problem spaces, integrating ideas and generating various solution ideas are elements of the ill-structured problem solving process as it is conceptualized in Sinnott’s (1989) and Jonassen’s (1997) ISPS model. Both Sinnott and Jonassen highlight that the most important part of ISPS is to identify the appropriate problem space among the multiple competing representations.

Sinnott (1989) has even argued that the generation of possible solutions is a *creative exercise* that is made possible by bridges of associations between the problem spaces and is informed by the problem solver’s epistemic beliefs of what counts as a valid solution. Finally, in the two aforementioned models of ISPS the problem solver selects a solution for which she was able to construct a persuasive argument. Thus, one can reasonably argue that creative problem solving is a form of problem solving manifested in ill-structured problems, which call for an original and effective solution.

The creative problem solving process as it is conceptualized in the four models of creative problem solving and especially the models proposed by Wallas and by Mumford and colleagues has similar cognitive elements with Sinnott’s Model for Solution of Ill-structured Problems (1989) and Jonassen’s Instructional Design Model (1997). The advantage of the two CPS models is that they simulate a problem solving process that allows recursive, circular thinking in comparison to stage models of ISPS that represent the problem solving process as one-step-at-a-time serial-processing activity (e.g., Jonassen’s Design Theory of Problem Solving). Thus, the study of the effects of argumentation scaffolds in creative problem solving is theoretically framed based on the model of the creative process proposed by Mumford and his colleagues (1991) because it allows recursive thinking while the problem solver attempts to develop an original and effective solution to an ill-structured problem, and because the researchers have proposed a model that explains idea evaluation, which is the focus of the present empirical study.
What has contributed in the development of the creative problem solving research as a different paradigm is the impact of the work of Guilford (1956) on the Structure of the Intellect and the work of Torrance with respect to the development of the Torrance’s Test of Creative Thinking (1986). Both theorists argued that creativity involves divergent thinking. Divergent thinking is defined as the ability to generate various ideas and is assessed using four indicators: fluency (number of ideas), flexibility (number of different types ideas), originality (uncommon ideas) and elaboration (enrichment of ideas).

Both Guilford (1950) and Torrance (1988) argued that divergent thinking is an indicator of creativity and idea generation is a basic cognitive component of creative problem solving. Thus, researchers who examined creative problem solving have traditionally included in their designs independent variables such as divergent thinking, intelligence, and personality type and less often measures of domain knowledge. This research approach has resulted in a relatively general, domain independent creative problem solving paradigm (Diakidoy & Constantinou, 2001). However, the ability to generate a large number of ideas does not ensure that the solutions will be innovative and effective. In fact, Weisberg (2006) argued that the domain-specific knowledge and domain relevant strategic knowledge that individuals bring to a problem, allows them to incorporate, elaborate, and extend their knowledge in order to develop creative breakthroughs.

In the upcoming section I will present and compare the variables (e.g., cognitive, metacognitive, and affective), which were found to predict or be associated with ISPS and CPS, in order to explore whether there is a set of unique variables that contribute in solving problems which require original and effective solutions.

**General Intellectual Abilities**

Researchers who examine creative problem solving typically measure two general intellectual variables including intelligence and divergent thinking. Intelligence was conceptualized as fluid intelligence and it was typically operationalized as students’ verbal reasoning ability (Sternberg & O’Hara, 1999). Intelligence was found to predict the quality and originality of solutions as well as the quality of the creative problem solving process such as the construction of a representation, encoding of
information, integration of ideas and generation of new ideas (Antes & Mumford, 2009; Reiter-Palmon et al., 1997; Osburn & Mumford, 2006; Mumford et al., 2001; Mumford et al., 1997; Mumford et al., 1996). However, divergent thinking was found to be a stronger predictor of the quality of solutions proposed to creative problems in comparison to verbal reasoning (Mumford et al., 1997).

Divergent thinking is defined as the ability to generate numerous varied ideas (Runco, 2007). Several studies indicated that divergent thinking has positive effects on the degree of originality and quality of solutions (Hunter, et al., 2008; Reiter-Palmon, 2009; Reiter-Palmon, et al., 1997; Osburn & Mumford, 2006; Diakidoy & Constantinou, 2001). Four indices have been used to operationalize divergent thinking: fluency, originality, flexibility, and elaboration. However, researchers typically score participants’ responses to creative problem solving tasks for fluency (i.e., the number of responses generated) because fluency scores have positive relations with other divergent thinking indices such as flexibility and originality (Lonergan, Scott, Mumford, 2004).

The tasks that are typically administered to assess divergent thinking are either verbal or figural and ask participants to generate unusual uses for objects (e.g., uses of a brick), instances of concepts (e.g., round things), consequences to hypothetical events (e.g., people did not need to sleep), and similarities between concepts (Silvia et al., 2008). Such divergent thinking tasks capture the ability to generate varied responses but they have been criticized for their usefulness as indicators of creative thinking since fluency is not sufficient for the development of creative ideas (Weisberg, 2006). Solving problems within a domain requires domain-specific expertise because the facts, concepts, principles and cognitive processes that characterize a domain are critical for one to be able to produce original and effective solutions.

Knowledge Variables

**Domain and structural knowledge.** Knowledge of important facts and concepts referred to as declarative knowledge, as well as knowledge of concepts and principles in a domain and the way concepts are related and organized are positive predictors of ISPS performance. Individuals with high levels of knowledge were found to perform better in ISPS. For example, Osana, Tucker & Bennet (2003) in a study of social studies decision making problems found that high school students used their
knowledge about the concept of equity to make decisions about how to distribute scholarship funds.

Domain specific knowledge guides the search of critical relevant information (Voss & Post, 1988). In fact, evidence in a study of problem solving in the domain of basketball showed that undergraduates with rich domain-specific knowledge searched for relevant information, represented the problem more comprehensively, and performed better in ill-structured problems in comparison to novices (Devine & Kozlowski, 1995).

Not only the breadth of domain knowledge but also the organization of concepts is a predictor of ISPS performance. Shin, Jonassen, and McGee (2003) found that middle schoolers’ knowledge of astronomy concepts and an understanding of their relations predicted problem solving performance and transfer in astronomy. Interestingly, applying more than one type of knowledge organization structures has the potential to facilitate the production of more creative solutions. In a study conducted by Hunter et al. (2008) the researchers prompted undergraduate students to use multiple knowledge structures (i.e., schema, associations, and cases). In this case, they found that the activation of schema or associations with case-based knowledge resulted in solutions that were of higher quality and originality in comparison with the solutions proposed by individuals who were prompted to use only a single knowledge organizational pattern.

Well organized and integrated knowledge is important to both CPS and ISPS. Additional evidence for this is provided by studies which examined the effects of structure supports that facilitated students in organizing their knowledge. For example, Chen and Bradshaw (2007) examined the effects of knowledge integration prompts in comparison to prompts which supported the problem solving process, and they found that the knowledge integration prompts improved problem representation, monitoring and evaluation of a solution and contributed to higher overall problem solving performance. In general, well integrated domain knowledge makes processing more flexible as organized knowledge is more readily retrievable and integrated knowledge contributes in more strategic processing.

**Strategic knowledge.** Strategic knowledge is defined by Alexander, Schallert, and Hare (1991, p. 329) as the awareness of “a process or procedure that permits the completion of a given cognitive task”.

Several domain general strategies that contribute to ISPS performance have been identified in the literature including means end-analysis, decomposition into subproblems, conversion into another problem more readily solved, and hypothesis testing (Jonassen, 1997; Voss & Means, 1989).

In creative problem solving the use of analogy is critical for the generation of new ideas through the combination and reorganization of structural knowledge. The use of analogy as a mechanism for creating an innovative idea is based on the process of mapping in which the problem solver “uses systematic connections between the sources and target to generate plausible, although fallible inferences about the target” (Holyoak, 2004, p. 117). Specifically, Mumford and colleagues found that problem solvers use metaphor which is another type of analogy as a search strategy to identify connections between knowledge structures when the relations are more abstract and the knowledge structures are more diverse (Mumford, Baughman, Maher, Costanza, & Supinski, 1997).

Domain specific strategies are stronger predictors of problem solving performance than the aforementioned general strategies. Strategic knowledge is acquired via experiences which provide opportunities to use and organize information within a domain (Voss et al., 1983). Examples of domain specific strategies include historical analysis conducted in international relations problems (Voss et al., 1991), analysis of causal factors accounting for students’ behavioral problems (Hew & Knapczyk, 2007), and proactive action in platoon leadership problems (Schunn, McGregor, & Saner, 2005).

What distinguishes experts from novices in terms of their strategic knowledge is not the number of strategies that they have available in their repertoire but rather the selection of strategies. When experts’ strategic knowledge was examined by Schunn and colleagues (2005) they found that experts in platoon leadership neither knew more strategies nor used more strategies to solve problems in comparison to novices. Rather, experts were more effective in selecting strategies based on the features of a situation and by taking into consideration the overall success of the strategies in previous problem situations they dealt with. Strategy selection by experts is more effective for two reasons: 1) experts focus on germane, relevant, and contradictory contextual information both qualitative and quantitative in order to construct the problem space and 2) experts develop patterns of organization based on the problem context, which
are easily retrievable when experts encounter similar problems. According to Voss and colleagues (1983, p.208) the patterns of knowledge organization developed by the experts’ application of strategies are similar to the procedural knowledge in Anderson’s ACT model because experts apply strategic knowledge as a set of procedures to solve particular problems.

Regulation of Cognition

Regulation of cognition includes three components: planning, monitoring, and evaluation (Schraw, Crippen, & Hartley, 2006). In ill-structured problem solving, planning contributes in identifying the goals, selecting important information from the problem statement, and activating relevant background conceptual knowledge and problem solving procedures, and regulating effort and time. Monitoring helps problem solvers to assess their progress towards the goals, determine whether their problem solving strategies are sufficient, and modify their plan if the problem solving approach does not contribute to progress or does not fit the goals and constraints of the problem representation. Thus, problem solvers who monitor well are able to consider perspectives, revise a solution and if any assumptions, problem parameters or constraints are violated then the problem solver re-represents the problem and plans accordingly based on the new problem representation (Osana, et al., 2003; Shin et al., 2003; Voss et al., 1991). Evidence from comparative studies of experts’ and novices’ self-regulatory activity (e.g., Jausovec, 1994; Vukman, 2005) showed that experts invest more time in planning and monitoring their problem solving activity in comparison to novices.

Solution evaluation includes the assessment of its effectiveness. The problem solver projects the consequences of implementing the idea, appraises the solution based on a set of standards and eventually either implements the solution or rejects it, or revises it to better address the task requirements and the context of implementation. Experts with more domain relevant knowledge engage more in the evaluation of a solution and examine the implications of the proposed solution in comparison to novices (Ge, Chen, & Davis, 2005; Jausovec, 1994; Voss et al., 1991). In fact, experts examine the ramifications of their solutions, forecast problems that may arise, and respond to these subproblems as they develop their solution (Voss et al., 1983).
Similarly, idea evaluation is an integral aspect of creative problem solving. Specifically, the extensiveness of the forecasts rather than forecasting potential negative outcomes predicted the creativity of a solution (Byrne et al., 2010). Such elaborative forecasting in which problem solvers consider a wide range of the implications of a solution positively predicted both the originality and quality of a solution (Byrne et al., 2010). Problem solvers involved in evaluating a potential solution to a creative problem seem to face an additional challenge as they have to evaluate the solution based on a standard (i.e., creative) that they need to define.

There is evidence to suggest that individuals underestimate the originality of original ideas, which may lead to the premature rejection of such solutions but the evidence comes primarily from studies that asked participants to judge the creativity of presented solutions (Blair & Mumford, 2007; Licuanan, Dailey, & Mumford, 2007). However, Runco and Smith (1992) argued that “there are significant differences between intrapersonal and interpersonal evaluations” (p.296) in terms of the processes, strategies and knowledge that individuals have to draw upon to produce accurate evaluations of their ideas. Thus, the extent to which the requirement for generating a creative solution affects the solution evaluation process needs to be better documented with empirical evidence. Solution evaluation is a core self-regulatory component of ill-structured problem solving that illustrates the circular nature of ISPS and CPS as individuals explore the implications of the solution and may isolate subproblems that require them to revise the solution by generating more ideas.

**Argumentation Skills**

Argumentation skills refer to the ability to formulate and weigh arguments for and against a course of action, a point of view, or a solution to a problem and they include the skill to generate reasons, offer evidence, and provide counterarguments and rebuttals (Kuhn, 1991). When problem solvers engage in ISPS they develop a case for the solution they propose by constructing an argument to support that the selected solution is the most viable solution given that there is not a single, best solution in ill-structured problems. Thus, argumentation becomes a means for problem solvers to evaluate and justify a proposed solution, identify potential problems in the implementation of the solution, and elaborate or clarify aspects
of the solution (Voss et al., 1981). The ability to justify a solution by generating arguments and providing evidence to support the solution was found to predict problem solving performance. For example, Shin and colleagues (2003) in a study of the performance predictors of well and ill-structured problem solving found that structural knowledge, justification skills, and positive science attitudes positively predicted ill-structured problem solving. In addition, experts in a domain spent a large amount of time in developing an argument and they were more persuasive about the solutions they put forward as they drew on relevant domain knowledge to argue about the viability of the solution.

Moreover, participation in a group discussion to establish solution criteria using argumentation was found to be a significant positive predictor of subsequent individual performance on well and ill-structured science problems (Kapur & Kinzer, 2009). Also, in a study that compared complex mathematical problem solving in individuals and dyads, researchers found that the dyads, which developed more coherent argument structures during problem solving dialogues were more successful. Dyads engaged in argumentation especially during the exploration and development of the problem space and solution (Vye, Goldman, Voss, Hmelo, &Williams, 1997). Specifically, students in dyads, used argumentation to explain something to the partner or to evaluate something that a partner proposed by explicating a counterargument.

Being able to develop coherent and compelling arguments to support the viability of a proposed solution is an important skill in solving ill-structured problems for which there is no consensus for a single solution. Arguably, in problems that call for creative solutions, problem solvers need to argue that the generated solution is both original and effective. In order to develop a compelling argument, individuals evaluate the consequences of implementing a solution and appraise the solution considering both a selected set of standards and the implementation context. The argument that problem solvers develop based on the evaluation of a solution can lead to a number of decisions such as to accept it as it is and implement it, revise it, or reject it. However, the degree to which argumentation skills contribute in the generation and evaluation of a creative solution needs to be better documented empirically.
Motivational and Affective Variables

Researchers have investigated the effect of motivational and affective constructs such as students’ need for cognition, self-efficacy, task-value and domain attitudes. Need for cognition which represents “an individual’s tendency to engage in and enjoy effortful endeavors” (Cacioppo, Petty, & Kao, 1984), positively predicted the quality and originality of problem solutions when individuals worked on problems that required creative solutions. However, there is not sufficient evidence regarding the role of need for cognition in ISPS.

In terms of the impact of self-efficacy, in two studies conducted by Lodewyk and his colleagues (2009; 2005) to investigate the effects of task structure on self-efficacy and self-regulation, they found that higher self-efficacy predicted performance on ill-structured problems even after controlling the effect of general academic achievement. In creative problem solving, self-efficacy beliefs may interact with a problem solver’s perceptions of a task. Reiter-Palmer and colleagues (2009) found that highly efficacious individuals, who perceived the problem to be less complex, generated more solutions but fewer original solutions. On the other hand, less efficacious individuals who perceived the problem to be more complex produced fewer solutions of lower quality. Further research with problems that require creative solutions is needed to establish the role of self-efficacy and whether it interacts with other affect-related variables such as task perceptions.

Finally, in a study which examined the cognitive and affective components that predict success in well and ill-structured problem solving in the domain of astronomy, Shin and his colleagues (2003) found that higher task value and positive domain attitudes towards astronomy were predictors of successful performance. Positive task appraisal and attitudes are important because students who value the task and experience positive feelings during the task are more likely to persist during a complex task.

Epistemological Beliefs

An individual’s beliefs about the nature and the structure of knowledge, including ideas about the sources of knowledge, the kind of justification required for public verifiability, the truth value and the limits of knowledge (Hofer & Pintrich, 2002) predict students’ success in ill-structured problem solving.
In order to examine the role of epistemic cognition in ISPS, researchers administered self-report measures of epistemic beliefs either the Shommer’s Epistemological Questionnaire (1990) or the Epistemic Beliefs Inventory (Schraw, Bendixen, & Dunkle, 2002). Schommer’s Epistemological Questionnaire (EQ) assesses four dimensions of personal epistemology namely that learning is fixed, knowledge is isolated in bits and pieces, learning is quick and knowledge is stable. The Epistemic Beliefs Inventory (EBI) is another scale developed to measure epistemological beliefs designed with the intent to improve the reliability and validity of EQ and capture five dimensions instead of the four captured by EQ. The dimensions of the EBI include beliefs about the certainty and simplicity of knowledge, omniscient authority, quick learning and innate ability (Schraw et al., 2002).

Two main concerns are articulated in the literature with respect to the above two measures. First, EQ and EBI assess not only beliefs about knowledge and knowing but also beliefs about learning. Second, the inability to support all the hypothesized factor structures of epistemological beliefs (i.e., failure of omniscient authority to emerge as a factor) coupled with the low internal consistency of the subscales (DeBacker, Crowson, Beesly, Thoma, & Hestevold, 2008). Thus, the operationalization of epistemological beliefs that undergirds the EQ and EBI, and the psychometric limitations of these measures call for caution when interpreting results about the impact of epistemological beliefs on problem solving.

Epistemological beliefs that conceptualize learning as fixed and quick and knowledge as simple and certain predicted performance in ill-structured problems as well as how much individuals engaged in reflective judgment during problem solving (Lodewyk, 2007). Individually, belief in simple knowledge was found to be a strong positive predictor of performance in ill-structured tasks (Lodewyk, 2007; Oh & Jonassen, 2007). Interestingly, epistemic beliefs explained variation in success in ill-structured but not the well-structured problems (Lodewyk, 2007; Schraw et al., 1995). Performance on ISPS tasks is benefited by a solver’s more complex epistemic beliefs possibly because when one engages with complex and ambiguous problems invests more time and effort (Lodewyk, 2007) and avoids premature closure (Kruglanski, 1990).
There is not adequate evidence on the effects of epistemological beliefs or other belief variables on creative problem solving. However, in order to solve this type of ill-structured problems, which require individuals to produce creative solutions, problem solvers will have to rely partly on their ontological beliefs about the nature and properties of creative solutions in order to develop a problem representation, generate criteria to evaluate the solution and judge how creative a proposed solution is. Thus, ontological beliefs about creative solutions represent an affective variable that can potentially have great impact on creative problem solving.

**Creative Problem Solving: A type of Ill-structured Problem Solving**

General intellectual abilities, knowledge variables, affective variables and regulation of cognition were found to predict creative problem solving. Based on the comparison of the predictors of CPS and ISPS performance, one can argue that creative problem solving is a type of ill-structured problem solving. Variables such as structural and strategic knowledge, self-regulatory variables such as monitoring and solution evaluation predict performance in both problem solving activities.

A number of predictors were identified as unique for creative problem solving performance. For example, intelligence, divergent thinking, analogical reasoning, and need for cognition predicted the creativity of a solution. I present here three explanations of why the production of original and effective outcomes is accounted by these unique predictors. First, research in creative problem solving has been conducted under a more domain general research approach, which is evident in the types of tasks administered to investigate creative problem solving. For example, the typical tasks that have been used to examine creative problem solving include divergent thinking tasks found in the TTCT, associative tasks referred to as RAT, which were developed by Mednick and Mednick (1967), and tasks related to a field (e.g., marketing, business, education), which required low levels of domain specific knowledge. Thus, more domain general individual difference variables such as intelligence, divergent thinking and analogical reasoning explained creative performance in tasks that did not require high levels of domain knowledge.
An alternative explanation of the distinct role of general intellectual predictors in creative performance was offered by Weisberg (2006), who argued that both general expertise such as reasoning and arithmetic ability and domain expertise are critical aspects of creative thinking. Weisberg has cited evidence from case studies of well known creative advances such as Edison’s light bulb, the invention of the double helix and Beatles musical works, which suggest that domain specific expertise, is the foundation of creative problem solving. Moreover, general knowledge and skills such as logic, analogical and figural reasoning, and technological expertise also contribute to creative problem solving.

A third explanation of why a distinct motivational variable namely need for cognition was found to predict creative problem solving performance is offered by taking into account the additional requirement of novelty typical of problems which require a creative solution. Need for cognition has been conceptualized as the tendency to engage and enjoy effortful cognitive endeavors that require deep thinking in an effort to structure a situation and make it meaningful (Cacioppo et al., 1984; Cacioppo & Petty, 1982) in order to produce something original.

Creative problem solving is an example of a complex cognitive task that challenges individuals by requiring them to produce a novel solution. Problem solvers high in need for cognition engaged more in generating ideas and were found to be more fluent, flexible, and self-efficacious in creative problem solving tasks and produced solutions that were original and of high quality (Butler et al., 2003; Hunter et al., 2008; Osborn & Mumford, 2006). Future research needs to examine further the role of need for cognition in the development of creative solutions.

**Structure Supports in Complex Problem Solving**

Both ill-structured and creative problems are complex forms of problems. Problem solvers need to define the problem situation and construct a problem representation based on a scenario in which the initial state, operators, and/or goal state is not well specified. Problem solvers also need to draw on their prior knowledge, their perceptions of the task, and their beliefs (e.g., epistemic cognition) in order to develop a problem representation. Moreover, in tasks with low degree of structuredness, individuals engage in decision making about the concepts, principles, and strategies to use in order to select the most
viable solution. In addition, learners need to engage in reflective thinking in which they consider other potential views, perspectives, and opinions. Due to the fact that there are numerous possible solutions, problem solvers need to weigh the consequences of the alternatives and define a set of criteria for evaluating their own solution based on the characteristics of the problem situation such as the goals and constraints of the problem and the context in which the solution will be implemented.

Researchers have provided students with structure supports in order to facilitate the problem solving process and improve performance in complex problem-solving tasks. Researchers examined the effects of structure supports such as prompts, case studies, and argumentation scaffolds to reduce the degrees of freedom (Kapur & Kinzer, 2009) in a complex problem solving activity.

**Prompts.** In order to facilitate knowledge integration researchers sought out to explore the effect of structure supports, primarily question prompts and cases including case-libraries and case-based learning online environments. Well-organized knowledge is important for ISPS as it allows problem solvers to be more flexible and strategic in the construction of the problem space and it contributes in improved performance. Knowledge integration prompts served as organizers because they helped students to identify important concepts and their relationships and directed them to develop effective arguments relevant to the implementation of the solution (Chen & Bradshaw, 2007). Moreover, when undergraduate students solved problems that required creative solutions, prompts that activated multiple knowledge structures and specifically the combined activation of case-based patterns with either associations or schemas resulted to the generation of creative solutions, which were both original and of high quality (Hunter et al., 2008).

Question prompts that guided students’ problem solving process in an ill-structured task were found to be effective in improving both the process and the performance. Students who received process question prompts engaged in more metacognitive activities, including planning their problem solving, evaluating the solution by comparing it with other potential solutions as well as articulating arguments to justify the proposed solution (Ge & Land, 2003; Ge, Chen, & Davis, 2005). The effectiveness of the prompts seems to depend on the prior knowledge and problem solving competence (Ge et al., 2005).
Novice learners benefited more from the prompts in the development of a representation, monitoring of the process and evaluation of the solution.

**Cases.** Case studies are another type of structure support, which function as representations of experiences that learners have not had. Cases are stories that represent potential real world problems in a domain (Jonassen, 1997, p. 84). Case-based reasoning facilitates students in making inferences during problem solving. Studying cases before solving ill-structured problems had a positive effect on performance. For example, undergraduate students who accessed case libraries with stories of experts who developed food products outperformed the comparison group on a multiple-choice post-test assessing processes related to problem solving regarding a food product development problem. Participants commented that the cases helped them to make meaning of the presented problem and relate a problem situation with a concrete solution (Hernandez-Serano & Jonassen, 2003, p. 104).

Moreover, an online case-based environment for classroom management problems designed for practicing elementary school teachers (Choi & Lee, 2009), helped teachers to consider multiple perspectives when defining the problem, generate potential solutions, and to justify more effectively their solutions. Finally, training individuals with cases of real-world examples had a significant positive effect on the production of original solutions in a problem for which undergraduate students developed a plan for introducing new teaching methods to an experimental secondary school (Osburn & Mumford, 2006). Combining case-based and principle-based examples resulted in plans that were high both in quality and originality. In conclusion, structure supports such as prompts and case-studies that guide learners to organize their knowledge were found to promote the development of a meaningful representation of the problem situation and improve problem solving performance.

**Argumentation Scaffolds.** Another important component of ill-structured problem solving that challenges novices is the selection of the most viable solution and the development of a compelling argument to justify the selected solution. In addition, for problems that require creative solutions learners need to be reflective in their argumentation because of the extra challenge that this type of problem solving imposes. Individuals have to anticipate any reservations and objections towards a solution that is
novel and think critically to make a decision on how to proceed with the solution. Researchers have provided argumentation scaffolds as a potential way to support students’ reasoning and improve the quality of argumentation and overall problem solving performance.

**Collaborative Argumentation.** One way in which researchers have supported student argumentation during problem solving tasks is by engaging students in computer-supported collaborative learning (CSCL). In two exemplar studies researchers examined the effects of argumentation scaffolds provided in computer-supported collaborative environments to determine their impact on the quality of argumentation, the group problem solving performance and transfer to individual problem solving (i.e., Cho & Jonassen, 2002; Oh & Jonassen, 2007).

Undergraduate students worked in online discussion environments and were given scaffolds in the form of sentence openers that helped them explicate a solution, agree or disagree with one’s solution, provide evidence and elaborate about the solution (e.g., A scholar says..., My experience is..., I believe that ..., Research shows…). Argumentation scaffolds also came in the form of guidance questions (e.g., How can you verify the accuracy or value of your solution?). Another type of argumentation scaffolds found in collaborative discussion environments are referred to as constraint-based conversation scaffolds since they constrain students’ comments. Students can select their comments from a predetermined set of messages that model a form of argumentation (e.g., hypotheses, data, and principles). Computerized argumentation systems which support argumentation and organize, display and record a discussion in an argument diagram, help students to reflect and monitor their discussion better.

Argumentation scaffolds in CSCL improved the quality of the discussion in terms of the number of argument components such as claims about how to solve the problem and grounds (evidence) to justify the solution (Cho & Jonassen, 2002; Oh & Jonassen, 2007). Moreover, group problem-solving subprocesses especially the definition of a problem, selection of relevant information, generation and testing of hypotheses, the development of a solution and the evaluation of a solution also improved. Transfer effects from collaborative to individual argumentation were detected in the overall quality of argumentation. However, the researchers did not specify how exactly the quality of argumentation
changed. Finally, in both studies researchers did not detect statistically significant transfer of the effects of argumentation scaffolding on individual problem solving performance.

An explanation for the fact that argumentation scaffolds in online collaborative reasoning only had an effect on group problem solving performance and not on individual performance could be that working in a group requires a dialogic approach in problem solving, which is benefited more by the scaffolds. On the other hand, individual problem solving is a solitary activity and learners may not engage deeply in critical thinking by exploring different perspectives, positions and solutions when individually solving an ill-structured problem. Thus, in the absence of any scaffold, it is more likely that learners engage in case-building to support their solution rather than considering other perspectives, selecting the most promising, and reflecting on the solution in order to revise and improve it. While in collaborative problem solving individuals are called to respond to opposing opinions and solutions, in individual problem solving learners are not cued by others who hold opposing views. Students may need long-term and comprehensive opportunities for extended engagement in collaborative problem solving to effectively transfer and apply argumentation skills in individual problem solving.

Studies that investigated the effects of extended participation in collaborative reasoning discussions that aim to develop students’ argument schemas which are “mental representations of argumentative elements along with representations of arguments tactics, strategies, and principles” (Reznitskaya, et al., 2008, p.197), showed that collaborative argumentation enhances the quality of student writing. In dialogues structured around argumentation, students state claims, provide reasons, and offer counterarguments. Researchers found that elementary school students who participated in small-group discussions facilitated by a set of teaching strategies to scaffold inquiry, internalized the argumentation knowledge and strategies in their persuasive writing and included more arguments, counterarguments and rebuttals in their essays (Reznitskaya, et al. 2001). Moreover, students’ writing appeared to shift from monologic to more dialogic as students were able to incorporate other perspectives and multiple solutions.
Collaborative discourse was also found to be effective in promoting argumentation when it was combined with instruction on the basic concepts of argumentation and reading of multiple texts both persuasive and expository. For example, Marttunen and Laurinen (2006) found that middle school student-constructed argument diagrams were more elaborative and reflective and they included more arguments and themes after reading 3 texts and engaging in a dyadic conversation on the issue of genetically modified organisms. In addition, Kim (2001) found that when a metacognitive group monitoring activity was incorporated in collaborative reasoning discussions, it also contributed to more dialogic student writing (as cited in Reznitskaya et al., 2008a). Groups were guided to reflect on aspects of the discussion by reacting to questions such as “Did we talk about important ideas? and “Did we respond to others’ different views?” In their post-discussion essay students incorporated more counterarguments and rebuttals. Moreover, the essays provided evidence that the students were attentive to their thinking process by reflecting and evaluating their position on the issue.

In conclusion, argumentation knowledge and skills are developed and internalized by providing guided opportunities for students to get involved in discourse structured around arguments. Both individual arguments as well as peer dialogues showed signs of improvement after students engaged in a series of argument-focused collaborative activities. However, more research is needed to determine the degree to which collaborative argumentation as a type of social scaffold (Reznitskaya et al., 2001) improves not only the quality of discourse and individual argumentation skills but also the ability to learn about specific domain topics through arguing to reason critically, decision making and problem solving.

Directions. Besides collaborative reasoning and collaborative computer-supported argumentation for group discussions another means for facilitating argumentation not only in ill-structured problem solving but also other tasks such as writing is through the manipulation of directions. For example, when participants provided a wrong answer to a physics problem in which they had to predict the path of a falling object they were asked to counterargue by providing reasons why a person would hold an opposing position (i.e., the correct one). In this study, Nussbaum and Sinatra (2003) found that students who generated a counterargument when they had given a wrong solution had a more integrated
understanding of the problem situation and of the important underlying concepts. Thus, the more advanced argumentation skill of being able to provide counterarguments was found to contribute in problem solving and conceptual change.

Directions that aim to support student argumentation are not equally successful but their effectiveness varies depending on the goal that directions convey. For example, when undergraduate students were directed to write with the goal of persuading and convincing an audience rather than writing to explain their position or solution there is evidence to suggest that they engage in case-building (i.e., my-side bias), accompanied by a reduction in counterargumentation and lower overall quality of writing (Nussbaum & Kardash, 2005). Under the direction to persuade, participants tend to offer more reasons in justification of their position and fewer counterarguments.

Alternatively to general directions that require students to write in order to persuade, researchers have explored the effectiveness of more specific goals that guide students to generate all the argumentation components (i.e., reasons, evidence, counterarguments, and rebuttals). Feretti, MacArthur, and Dowdy (2000) found that providing 6th graders with specific goals to persuade had improved the overall quality of their persuasive essays and the number of argumentation components they explicated. Similarly, Nussbaum and Kardash (2005) compared three groups of undergraduate students who were given directions that differed in generality (i.e., opinion, reason, counterargue/rebut). For the group of undergraduate students who got more specific goal directions to produce reasons, evidence, counterarguments and rebuttals, their writing was overall of better quality, more balanced and the students offered significantly more counterclaims and rebuttals. Interestingly, there was an interaction between counterarguments and prior topic beliefs as students with more extreme beliefs generated fewer counterclaims.

The degree of generality of the directions in a task that involves argumentation may not completely explain the failure for explicating counterarguments. The purpose of a problem solving or writing task as it is conveyed in the directions could have a negative effect on the reasoning and argumentation due to the learners’ perceptions of the task. Several researchers pointed to a misconception
commonly held by students that elaborating on one’s position strengthens persuasiveness, but raising counterarguments has the opposite effect (e.g., Nussbaum, 2008; Nussbaum & Kardash, 2005). In the absence of modeling of appropriate argumentation schema it is more likely that students will resort to their beliefs about the relation between persuasion and argumentation, and downplay the importance of discussing opposing positions or solutions.

In an effort to develop students’ argumentation knowledge and promote deeper, reflective reasoning researchers have examined the effects of various interventions. Among the interventions are providing a non-refutational text to model balanced reasoning, defining the criteria of good argumentation, providing a visual aid such as a graphic organizer or having students construct individually or/and collaboratively an argumentation diagram. For example, Nussbaum and Kardash (2005) examined the effects of a balanced non-refutational text and goal instructions on written argumentation. The students who read a text on TV-violence and received directions to express their opinion on the issue rather than to persuade an audience produced essays of better overall quality. Students who read and responded to the opinion goal instructions wrote more elaborative arguments and offered significantly more counterarguments in comparison to those who did not read. On the other hand, participants who received directions to persuade and read the text did not generate more counterarguments.

Thus, the study confirmed the negative effects of persuasion directions on the overall quality of writing, and the generation of counterarguments and rebuttals when no text is provided to model balanced reasoning and to provide ideas that students could elaborate in their writing. A short-come of the text as an intervention to support argumentation is that it interacts with learners’ knowledge and beliefs. In this study reading a text did not benefit students with strong pre-existing topic beliefs since these students offered fewer counterarguments and rebuttals.

**Argument Diagrams.** Effective argumentation is not only characterized by a complete set of argumentative components but it is also organized and coherent with integrated arguments and counterarguments that support the overall final position. Integration is challenging for students and
researchers have investigated the effects of scaffolds such as instructions that explicitly describe a good argument and visual aids such as graphic organizers.

Figure 2.4. A graphic organizer to guide argumentation

Nussbaum and Schraw (2007) compared the effectiveness of instruction about the criteria of a good argument and a graphic organizer (see Figure 2.4) to facilitate undergraduate students in integrating arguments and counterarguments in support of a final position. Both methods had a positive effect on the number of counterarguments and the overall quality of students’ writing. Argument criteria instruction increased the overall integration score. Students who received criteria instruction used primarily two integration strategies - weighing arguments and counterclaims and synthesizing different perspectives into a new position. Students who used a graphic organizer produced more rebuttals and applied primarily the refutation strategy by picking one side and rebutting counterarguments to it. The combined condition had a negative effect on the overall quality and the number of counterarguments, which can be explained by the increased cognitive demands of following two sets of directions but also the possibility that students failed to transfer and integrate information from instruction to the graphic organizer.

The results of this study suggest that argumentation scaffolds intended to facilitate activation of an argumentation schema can cue different integration strategies (i.e., synthesizing, weighing, and refuting). Thus, when researchers select an argumentation intervention they need to consider the purpose of the writing, discussion, or problem solving task (e.g., persuasion, reflection, inquiry, evaluation, etc.). In ill-structured problem solving it would be valuable to design argumentation interventions that guide students to think critically and make well-reasoned judgments about potential challenges and objections.
to their ideas and constructively consider these perspectives either by weighing counter perspectives or by synthesizing ideas to come up with a new way to address an issue.

In order to facilitate students to become more metacognitively reflective in their writing by exploring various perspectives on an issue and integrating them into a final position, Nussbaum (2008) in a follow up study redesigned the graphic organizer to an Argumentation Vee Diagram (AVD). The revised diagram cues learners to integrate arguments and counterarguments using either the synthesis or weighing strategy (see Figure 1.1).

Nussbaum (2008) examined whether a more elaborative intervention that combines a graphic organizer (i.e., diagram) with instruction of how to integrate arguments and counterarguments, and discussion of the criteria for evaluating the relevant strength of arguments and counterarguments results in better argumentation. The experimental group improved their writing in terms of integration over time (3 sessions) but there was no significant difference between the experimental and control group in terms of transfer to a task without the use of an AVD. The most frequently used integration strategy was synthesis, and both weighing and rebutting were rarely applied. More integration emerged over time as participants practiced more with the diagrams and received instructions on how to evaluate counterclaims using criteria (i.e., prevalence and value of an advantage or disadvantage).

An important finding stemming from this study is that argumentative reasoning is challenging for young adults and scaffolding with diagrams such AVDs provides more guidance and structure, which leads to more elaborated arguments and reflective and integrative reasoning. However, as Scheur, Loll and Pinkward (2010) pointed, the effectiveness of an educational argumentation tool does not depend only on the diagram but it depends on the overall pedagogical approach including the sequencing of activities and instruction on how to use a diagram. Thus, the degree of effectiveness of an AVD may differ when it is used as a single element of an intervention compared to when it is a component of a more comprehensive argumentation intervention as it was implemented by Nussbaum (e.g., 2007; 2008).

In conclusion, researchers have examined the effectiveness of various argumentation scaffolds such as directions, texts, graphic organizers including argumentation diagrams, and collaborative
reasoning discussions. Directions that ask students to express an opinion on an issue, and are specific by explicating that students need to present counterarguments and rebut them, are more effective than general directions that ask learners to persuade an audience. When specific directions were supplemented with text(s) that model argumentation students who did not hold extreme beliefs on the topic demonstrated more elaborative argumentation.

Graphic organizers, for example, diagrams which make available to the learner an external argument representation were more successful in promoting reflective thinking and argumentation when they provided a way to visualize not only the argument elements but also the relations between the elements and the thinking processes such as integration of arguments and counterarguments. Argumentation Vee Diagrams have been used to stimulate consideration of counterarguments, integration of arguments and counterarguments, and to structure students thinking in terms of planning, summarizing and evaluating their argumentation (Nussbaum et al., 2007). Nevertheless, visual representations and collaborative reasoning are more effective scaffolds of argumentation when they are components of a more comprehensive and extensive instructional approach for promoting argumentation.

**Implications for Research and Practice**

According to Karl Popper all life is problem solving and cognitive and educational psychology researchers have made progress in determining cognitive and affective variables that promote effective problem solving. Creative problem solving is a type of ill-structured problem solving that calls for solutions which are original and effective. A well organized and integrated domain knowledge, strategic knowledge especially analogical reasoning, metacognitive monitoring and need for cognition are among the variables that predict creative solutions. However, creativity researchers have been invested more in examining the cognitive processes that lead to the generation of a creative solution and investigated less the nature and predictors of cognitive processes that close the loop of creative problem solving such as solution evaluation and implementation monitoring.

Solution evaluation refers to the process by which a problem solver forecasts the implications of a potential solution and judges the solution based on a number of criteria. Despite the fact that evaluation is
a significant metacognitive process since based on their judgments learners can revise and refine their solution ideas, reject them or implement them, researchers have not yet identified the spectrum of factors that impact this cognitive component of creative problem solving. Researchers need to turn their lenses to solution evaluation in order to gain a more comprehensive understanding of the process, its predictors and the type of structure supports that can promote critical and reflective thinking in the evaluation of potential solutions. A potential approach would be to examine how evaluation is manifested in experts’ creative problem solving and what challenges novices and younger children face when they are called to reflect and judge their solutions.

Researchers invested in understanding complex forms of problem solving have explored a number of structure supports that reduce the free parameters in ill-structured problems and guide students reasoning and problem solving processes. Practitioners who aim to develop students’ problem solving skills can use verbal or visual scaffolds to promote integration of domain knowledge (e.g., case studies, graphic organizers), procedural and reflective prompts (e.g., questions, sentence openers, goal instructions) to support the problem solving process and engage students in critical thinking while they are generating and evaluating potential solutions. Practitioners need not only attend to learners’ cognition but also their affect associated with complex problem solving. Classroom discussions that encourage students to explicate their beliefs about creative solutions and acknowledge their agency as problem solvers especially in judging and arguing about the effectiveness and innovativeness of a solution, have the potential to promote a more dialogic approach in creative problem solving.
CHAPTER 3

Methods

The purpose of the study was to explore creative problem solving performance and examine ways to support reflective self-evaluations of the proposed creative solutions. The methods chapter describes the sample and presents the measures, and the two tasks administered in the study: the problem solving and reflective tasks (e.g., Explanation or Argumentation). Finally, the methods chapter summarizes the experimental procedures of this single-factor, between-groups design study with two comparison groups.

Pilot Administrations

Two pilot study administrations were conducted prior to this dissertation study to examine the comprehensibility and the psychometric properties of the measures and tasks developed for use in the present study. Specifically, the two pilot studies were executed to determine (a) the understandability of the individual difference measures (e.g., divergent thinking, creative course beliefs questionnaire), the problem scenario, and the problem solving and reflective tasks, (b) the face validity of the problem solving and reflective tasks based on the alignment of the responses with the intended purposes of the tasks, and (c) the reliability of scores assigned to the divergent thinking tasks, the beliefs questionnaire, the need for cognition questionnaire and the self-evaluation questionnaire. In addition, the two pilot studies were conducted to develop a coding scheme to analyze and summarize student responses to the problem scenario.

Nineteen undergraduate students in an introductory educational psychology class and a graduate student participated in the first pilot administration. Ten undergraduate students in another introductory educational psychology class participated in the second pilot administration. In total, twenty eight students provided usable responses for further data analysis ($n_1=19$; $n_2=9$). Half of the participants were female, 61% were education majors ($n=17$), 32% were non education majors ($n=9$), and two were undecided. Several of the pilot participants were sophomores (36%), some were freshman (25%) or juniors (21%). There were only 2 seniors, 1 PhD student, and one student seeking certification.
Participants were assigned to one of three experimental conditions based on a ratio of 2:2:1. The three experimental conditions were: (a) Explanation ($n_1=12$), (b) Argumentation ($n_2=10$), and (c) comparison ($n_3=6$). The pilot experimental conditions were formed based on the reflective tasks that participants completed after they had responded to the problem solving task. Three types of reflective tasks were included in the pilot administrations and depending on the condition participants provided an explanation, completed an argumentation diagram, or filled in a pros/cons grid about the creative solution they proposed. The third condition was included in the experimental design for exploratory reasons to gauge and compare students’ responses to the two reflective tasks with different advanced organizers (i.e., argumentation diagram and pros/cons grid). Both pilot administrations were based on a paper and pencil format.

Following the first pilot study, two focus group discussions were conducted with 11 volunteer participants ($n_1=6; n_2=5$) who had completed the study materials. An interview protocol was developed for the focus group discussions to guide the collection of information about the clarity of the measures and the problem solving scenario, and gather evidence of face validity for the problem solving and reflective tasks. The results of the first pilot study and the focus group discussions pointed to the need for minor revisions to improve comprehensibility, reliability, and the face validity of the materials. The second pilot administration was conducted to examine whether the modifications made to the measures, the problem scenario, and the problem solving and reflective tasks improved the comprehensibility and the psychometric properties of the measures. Moreover, two advanced educational psychology students completed the paper and pencil pilot and six individuals with expertise in education (e.g., advanced graduate students and research associates) responded to the online version of the present study to provide further content and face validity evidence. The section that follows under the heading ‘measures’ presents a detailed description of the measures and their psychometric properties along with a discussion of how the measures and tasks were revised based on the results of the two pilot studies and the focus group discussions.
Participants

The participants for this dissertation study were undergraduate students who were recruited in person by the researcher from a section of an introductory educational psychology course. One-hundred twenty five students voluntarily participated in the study and received extra credit as compensation. The completion rate was 82% (n=103). Eleven individuals were excluded from further analysis as they either did not respond to one of the two major portions of the study (i.e., problem solving or reflective task). Seven more cases were excluded because they provided vague, broad, or uncodable responses to the problem solving task. Finally, four individuals misinterpreted the divergent thinking task and failed to provide any valid ideas. As a result, these individuals were also excluded from the sample.

The participants were education majors 57%, another 40% were non-education majors from disciplines such as communication sciences and disorders, kinesiology and mathematics, and 3% reported being under the division of undergraduate studies (DUS). Several students were sophomores 52%, nearly a third were freshmen 30%, followed by a 13% of juniors, a small percentage of students were seniors (4%), and one student was seeking certification (1%). The gender and ethnicity in this participant group was representative of the student population in the College of Education. Most of the participants were female (n=88) and the majority of the students (89%) identified themselves as White, Caucasian or White Caucasian, and 3% were Hispanic White. Few students (8%) represented other minority groups such as African American, Biracial, Chinese American, and Middle Eastern. From the sample of 103 participants, 93 participants reported their GPA and the average GPA was $M=3.47(0.41)$ on a scale with a maximum value of four.

The specific group of students was considered appropriate for examining creative problem solving in a design problem for two main reasons. First, half of the students registered in the introductory educational psychology course on learning and instruction are education majors or following a teaching track in their field. Thus, the participants are likely to become involved in formal or informal teaching when they graduate and the problem scenario and problem solving task administered in this study, is assumed to interest them since the task pertains to an educational issue. In fact, 80% of the participants
reported that they have previous formal or informal teaching experience. Examples of formal teaching experience included coaching (18%), internships in schools (17%), independent teaching (12%), and teaching assistantships (10%). Several participants had informal teaching experience that included camp counseling/leadership (17%), tutoring (12%), and other work with children, in settings such as in after school care units or pre-school units (14%). In sum, the majority of the participants were involved either in formal or informal teaching and some had broader teaching experience both informal and formal.

Secondly, for this study the problem solving task required participants to design a creative high school course to prepare students for college. Thus, the task was judged to be appropriate for the participants because it is unlikely that students enrolled in this introductory course would have prior experience with designing such a course, which makes the task sufficiently unique and ill-structured for the participants. When students were asked to briefly describe any courses they took to prepare them for the transition to college, 79% of the participants identified a course or other experience that helped them with the transition such as advanced placement courses (55%). Participants also identified introductory college courses such as English (18%), the 1st year seminar (9%), speech classes (5%), and honor courses (5%) as preparatory experiences for college transition.

An *a priori* power analysis was conducted to determine the desired sample for this study given a large effect size ($f^2=0.35$) when a linear multiple regression model is performed to analyze the data. The *a priori* power analysis indicated a desired total sample size of 59 participants with 30 students in each condition ($R^2=0.26$, $\alpha=0.05$). Given a medium effect size ($f^2=0.15$) based on Cohen’s (1988) levels of effect sizes the total desired sample size is 129 participants with 65 individuals assigned to each condition ($R^2=0.13$, $\alpha=0.05$). Because the univariate multiple regression is more powerful than the multivariate, a sample size that is sufficient for the univariate multiple regression will be sufficient to yield a significant effect for the multivariate regression model performed to answer the fourth research question. In the final sample of 103 students the distribution in the two experimental conditions was 53 students for the explanation task and 50 for the argumentation task completed after proposing a solution to the problem solving task.
Measures

Demographics. A demographic cover page was administered to collect background information regarding participants’ gender, ethnicity, major and minor areas of academic study, academic classification, and grade point average. Participants also recorded courses that they had taken to prepare them for the transition to college. In addition, students were asked to list the titles of courses they had completed relevant to curriculum and instructional design and the number of courses that students recorded was used as the proxy of prior knowledge. The participants were currently enrolled in an introductory psychology course on Learning and Instruction (EDPSY14), which also covers instructional design topics such as learning and motivation theories, methods of instruction and assessment techniques. For the participants who did not list this as a course relevant to instructional design, EDPSY14 was added to their list of courses. The majority of the students had some prior knowledge of curriculum and instructional design (see Table 3.1). Indeed, 64% of the participants had taken at least one course relevant to curriculum and instructional design, while the remaining students had taken more than one course.

Table 3.1

<table>
<thead>
<tr>
<th>Courses</th>
<th>( f )</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>67</td>
<td>64</td>
</tr>
<tr>
<td>2</td>
<td>20</td>
<td>19</td>
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<tr>
<td>3</td>
<td>11</td>
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<tr>
<td>4</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>5</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

Finally, participants were asked to list and describe any previous teaching experiences they acquired. Participants recorded several teaching experiences both formal and informal and based on the nature of the teaching experiences coding categories were developed to summarize them. Examples of formal activities are independent teaching, teaching assistantship or internship in a school as well as
coaching. Categories that summarize informal teaching experiences include camp counseling, tutoring, and child care (e.g., preschool, after school program).

**Divergent Thinking Tasks.** Two out of the five divergent thinking tasks were derived from Guilford’s Consequences’ Test A (Christensen, Merrifield, & Guilford, 1953). Administration of the Guilford’s Consequences’ Test A’ followed the guidelines provided by Hocevar (1979). Students had two minutes for each task during which they generated as many consequences or possible results to a hypothetical situation describing a type of change. The prompts for the two divergent thinking tasks were:

1. What would happen if a new invention makes it unnecessary for people to eat?

2. What would happen if a new invention makes it unnecessary for people to sleep?

The two questions described two unrealistic hypothetical scenarios. An elaboration to each question prompt was added to clarify that the situation is imaginary and to promote comprehensibility. This elaboration prompt was added to each of the two questions for the second pilot study administration because some responses from a minority of participants in the first pilot administration suggested that a few participants misinterpreted the imaginary hypothetical scenarios and perceived them as negative and catastrophic innovations that threatened human survival. The elaboration prompt added to the questions was (a) So essentially people no longer need to eat and (b) So essentially people no longer need to sleep. The addition of each elaboration prompt reduced misinterpretation of the divergent thinking tasks in the second pilot study.

The responses to the two divergent thinking tasks were coded and scored for ideational fluency. According to Merrifield, Guilford, Christensen, and Frick (1962) ideational fluency is “*the production of ideas appropriate in meaning in response to a given idea*” (p. 3). Ideational fluency was selected as the only divergent thinking index for two reasons. First, due to the positive correlations observed between ideation fluency and other divergent thinking indices such as flexibility and originality (Hocevar, 1979; Lonergan, Scott, & Mumford, 2004). Second, an originality and effectiveness score was calculated
for the scoring of the responses to the problem solving task, which is the primary task of investigation in this study.

For the present study ideational fluency was operationalized as the total number of distinct appropriate ideas (i.e., valid) recorded by a respondent excluding any duplicates (i.e., exact or very similar paraphrase of an idea) or irrelevant ideas that did not align with the hypothetical scenario due to a misinterpretation of the divergent thinking task. This scoring approach parallels the guidelines of the revised scoring scheme proposed by Dela Rosa, Knapp, Katz, and Payne (as cited in Mathew, 2009) in which the estimates of ideational fluency and originality exclude any duplicates or irrelevant/unratable ideas.

**Coding.** Two coders, myself and an individual with a doctoral degree in educational psychology (Coder A), independently coded the data. The first step was to establish interrater agreement for the identification of the total number of idea units and the discrimination of valid ideas from duplicates or irrelevant ideas (i.e., valid from non valid). Valid ideas included any unique ideas, elaborations, or general statements that respondents proposed. Two training sessions were conducted before selecting a subset of data to establish interrater agreement in coding. First, myself and Coder A used a coding guide with descriptions of the coding categories to code the responses to the two divergent thinking tasks. The researcher used the initial guide to code all the data and Coder A used it to code more than half of the data (55%) for each of the two divergent thinking tasks. Following the initial coding round the coding scheme was further clarified through discussion of the codes and resolution of disagreements. Given that intercoder reliability depends not only on communicating the coding categories and directions but also on establishing a common set of assumptions and decision making rules (Hak & Bernts, 2009), the discussion resulted in a list of shared coding assumptions and decision rules.

Following, during a second training session, a subset (10%) of the previously coded cases was selected to practice coding using the refined coding scheme. In the instance of disagreements, the existing rules were elaborated to specify signifiers (e.g., if, because) that would function as category discriminators. During the discussion we reached agreement on most of the units that represented valid
ideas. Thus, we proceeded to independently code a random sample of 20% \( (n_{1,2}=23) \) of the responses that participants provided in each divergent thinking task to establish interrater agreement.

Each response to a divergent thinking task was coded for the total number of idea units and the number of valid ideas each participant generated in response to a divergent thinking task. Thus, intercoder agreement was estimated for both of these decisions. The Krippendorff’s \( \alpha \) (Kalpha) reliability index was the selected measure of intercoder agreement, which is somewhat conservative and thus a moderate criterion was selected with a value of .70 (Lombard, Snyder-Duch, & Bracken, 2010). Krippendorff’s \( \alpha \) is a standard reliability coefficient developed to measure the agreement between coders and its value ranges between 0 when coders agree due to chance (i.e., absence of reliability) and 1 when coders agree consistently. The main advantage of this index is that it takes into account agreement that could occur by chance. The formula for estimating \( \alpha \) (available in SPSS and SAS macros) allows researchers to judge their agreement in coding for a variety of data using the same reliability standard (\( \alpha \)) since the computational formula applies to any number of observers, level of measurement and both small and large sample sizes as well as in the case of occurrence of incomplete or missing data by a coder (Hayes & Krippendorff, 2007).

The Kalpha reliability indices for the total number of idea units in the two divergent thinking tasks were \( \alpha_1=.96 \) and \( \alpha_2=.76 \) respectively. The Kalpha coefficient for the number of valid ideas excluding duplicates and irrelevant ideas were \( \alpha_1=.83 \) and \( \alpha_2=.86 \) respectively for each of the divergent thinking tasks. Any disagreements in the total number of idea units were resolved through discussion to reach a consensus total number of idea units. Once the consensus total number of idea units was determined, any disagreements in the coding of an idea unit were resolved in a discussion to determine whether the idea represented a valid alternative (e.g., unique, elaboration, or general statement) or a nonvalid idea (e.g., duplicate or irrelevant).

Disagreements in coding of the divergent thinking responses were due to two main reasons: the differential coding of hypothetical statements that participants made about the scenario (e.g., if they lose weight by not eating) and differential coding of sequential similar examples that participants used to
illustrate an idea (e.g., people would also not spend time at Sheetz, Wawa, McDonalds, Wendys, etc).

Both of these instances represented special cases that were incorporated in the existent decision rules to better discriminate the coding of unique ideas from elaborations or duplicates. Finally, I used the refined coding guide to score the remaining responses to the two divergent thinking tasks (n=80, 78%).

In response to each of the two divergent thinking scenarios, the participants generated on average $M_1= 6.11 (2.46)$ ideas for the first task Divergent Thinking (I) and $M_2= 5.52 (2.27)$ ideas for the second task Divergent Thinking (II). Due to the low internal consistency coefficient for the two divergent thinking tasks ($\alpha=.63$) the two divergent thinking scores did not form a scale but were entered as separate divergent thinking indicators for data analysis.

**Creative Course Beliefs Questionnaire.** Students’ beliefs about the characteristics of a creative course were measured on a 28-item Likert scale (see Appendix C) and a composite served as an index of participants’ beliefs about creative outcomes. Students were directed to indicate how much they agree with each of the 28 statements on a 5-point Likert scale ranging from Not Very (0) to Very Much (5). Twelve of the items described characteristics of a creative course. Six of the items targeted characteristics of a creative course related to its originality (i.e., innovative, unusual, original, novel, unique, and imaginative). The other six items targeted characteristics related to the effectiveness of a creative course (i.e., effective, successful, affordable, implementable, goal-directed, and feasible). Two examples of items describing qualities of a creative course are provided here: (a) Creative high school courses are novel and (b) Creative high school courses are effective.

The characteristics of creative courses included in the beliefs questionnaire were identified as key terms that describe creative solutions in the extant theoretical and empirical literature of creativity and creative problem solving. The beliefs questionnaire was administered in the two pilot studies conducted with undergraduate students in introductory psychology classes to determine the comprehensibility and the psychometric properties of the measure. In the two focus group discussions that followed the first pilot administration some of the participants mentioned that items that were negatively expressed (e.g., Success in college is negatively predicted by weekly hours of group study) or items that contained the
phrase predicted (e.g., Success in college is positively predicted by one’s motivation to learn) were challenging for pilot participants to interpret. In addition, participants mentioned that they were not able to interpret what the term reliable meant for a creative course, thus the term was replaced by the characteristic goal-directed in future administrations of the measure. Moreover, based on the comments that pilot study participants made the phrasing of some items in the beliefs questionnaire was revised. Specifically, the sentences were modified from passive to active voice, the word predicted was replaced with the phrase “associated” or “related with”, and the sentences that included a negative phrase were rewritten with a positive tone such as “Fewer weekly hours of study are positively related with success in college” instead of “Success in college is negatively predicted by weekly hours of group study”.

The remaining 16 items were distracters related to two conceptual categories. The first category with eight distracters pertained to factors associated with academic success in college. An example item is “Success in college is positively related with parents’ education level.” Another set of eight distracter items pertained to beliefs about curriculum and curriculum design. These items were modified items drawn from the Science Curriculum Orientation Inventory (Cheung & Ng, 2001) that measures secondary school teachers’ beliefs about curriculum design. An example of a distracter item from this conceptual category is “The priority in curriculum design is to develop students’ understanding of theories.”

In order to determine the underlying structure of the belief scale data were submitted to an exploratory factor analysis with a principal axis factoring (PAF) extraction and a Promax rotation. The Promax rotation was selected because is a type of oblique rotation that aids the interpretation of the factor analysis results when the factors are believed to be correlated (Costello & Osborne, 2005). In the case of beliefs about creative courses there were two hypothesized underlying dimension beliefs about the originality and effectiveness of the creative course, which are expected to be correlated. Indeed the intercorrelation between the two first factors was moderate to high ($r_{12} = .57$). When only the 12 characteristics of creative courses were used for the factor analysis three factors were extracted with eigenvalues of 37.066, 10.688, and 6.996 respectively. The three factor eigenvalues are greater than the criterion of 1.0 based on the Kaiser-Guttman rule (Guttman, 1954; Kaiser, 1960).
An overview of the scree plot indicated two underlying factors. Only the characteristic affordable loaded on the 3rd factor, which explained 6.996% of the data. The characteristic affordable was the only item that targeted financial aspects of a creative course and this is possibly why this characteristic failed to load on the two first factors that represented the effectiveness and originality of a course. Consequently the item that loaded on the third factor was eliminated and another factor analysis (PAF) with a Promax rotation was conducted using the remaining 11 items that loaded on one of the first two factors. The final analysis extracted two factors with eigenvalues 4.828 and 1.497, which explained 39.984% and 9.917% of the variation in the data respectively. The two factors represent underlying characteristics of creative courses with the first factor representing the effectiveness dimension and the second factor representing the originality dimension of a creative course. The factor intercorrelation remained moderate to high ($r_{12} = .57$). Table 3.2 displays the loadings of each characteristic of creative courses on the two factors in the pattern matrix.

As it is indicated in Table 3.2, nine coefficients have loadings greater than the Harman criterion value of four and load either on the effectiveness dimension or the originality dimension of beliefs about creative courses. Characteristics that underlie the effectiveness of a creative course included successful, effective, innovative, implementable, and feasible. Characteristics that underlie the originality dimension of a creative course included the characteristics imaginative, unique, novel, and original. The characteristic innovative loaded on the effectiveness component while it was expected to align with the originality than the effectiveness dimension of a course. This is possibly explained by the fact that the characteristics under the originality dimension are semantically more identical (i.e., imaginative, unique, original) in comparison to the characteristic innovative.

The Cronbach $\alpha$ internal consistency coefficient for the beliefs scale with the nine belief items was $\alpha = .87$, which is acceptable as it is above the criterion .80. The internal consistency of the two components were $\alpha = .84$ for effectiveness and $\alpha = .81$ for originality.
Table 3.2

*Coefficients for the Exploratory Factor Analysis with Direct Oblimin Rotation for the Beliefs Scale*

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Effectiveness</th>
<th>Originality</th>
</tr>
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<tbody>
<tr>
<td>Successful</td>
<td>.998</td>
<td>-.153</td>
</tr>
<tr>
<td>Effective</td>
<td>.959</td>
<td>-.195</td>
</tr>
<tr>
<td>Innovative</td>
<td>.605</td>
<td>.070</td>
</tr>
<tr>
<td>Implementable</td>
<td>.509</td>
<td>.181</td>
</tr>
<tr>
<td>Feasible</td>
<td>.440</td>
<td>.169</td>
</tr>
<tr>
<td>Imaginative</td>
<td>.004</td>
<td>.812</td>
</tr>
<tr>
<td>Unique</td>
<td>.081</td>
<td>.757</td>
</tr>
<tr>
<td>Novel</td>
<td>.095</td>
<td>.619</td>
</tr>
<tr>
<td>Original</td>
<td>.233</td>
<td>.619</td>
</tr>
<tr>
<td>Unusual</td>
<td>-.231</td>
<td>.367</td>
</tr>
<tr>
<td>Goal-directed</td>
<td>.325</td>
<td>.307</td>
</tr>
<tr>
<td>Eigenvalues</td>
<td>4.828</td>
<td>1.497</td>
</tr>
<tr>
<td>Percentage of</td>
<td>39.984</td>
<td>9.917</td>
</tr>
<tr>
<td>Variance</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Note.* Factor loadings >.4 are in bold

A composite score was calculated based on the nine characteristics to represent the creative course beliefs scale which ranged from 0 to 45 with higher scores indicating beliefs that are in agreement with the characteristics of creative outcomes. The mean score on this scale was $M=26.89$ (7.29), which illustrates that participants’ beliefs are in moderate alignment with the characteristics of creative outcomes.

**Need for Cognition Scale.** The Need for Cognition measure assesses an individual’s tendency to engage in and enjoy effortful cognitive endeavors (Cacioppo, Petty, & Kao, 1984, p. 306). In this experimental study participants completed the revised 18-item Short Need for Cognition Scale (Cacioppo, et al., 1984) that was titled Learning Preferences questionnaire. Cacioppo et al. (1984) found that the short form of the Need for Cognition scale was similarly reliable and valid as the 34-item original Need
for Cognition Scale. In addition, a principal components analysis indicated that 37% of the variance in the 18-item short form was attributed to the one dominant factor (i.e., Need for Cognition) in comparison to 27% of the variance explained by this primary factor in the long version. Moreover, the short form of the Need for Cognition was found to be reliable with a high internal consistency index of .90.

For the Need for Cognition Scale the students were instructed to indicate the extent to which the characteristic highlighted in each of the 18 statements describes them on a Likert scale ranging from Not Very Much (0) to Very Much (5). The Need for Cognition score was a composite based on the sum of all items on the scale after nine of the eighteen items were reverse coded. The Need for Cognition score ranged from 0 to 90 with higher values representing higher tendency to engage and enjoy cognitively demanding tasks. The reliability coefficient for the Need for Cognition scale was at an acceptable level $\alpha=.79$ close to the cut-off criterion of .80 (Garson, 2011). Thus, a composite Need for Cognition score was calculated and it ranged from 0 to 90. On average, students were low in need of cognition as the mean score was $M=48.5$ (10.46).

**Solution Self-Evaluation Questionnaire.** Participants evaluated their proposed creative solution using a self-evaluation questionnaire that included a set of characteristics that describe creative outcomes. Specifically, the solution self-evaluation questionnaire included 16 items of which 14 were characteristics that describe creative outcomes and two items were distracters. Twelve of the 14 items were identical to the items included in the beliefs questionnaire and they reflected descriptive characteristics of creative outcomes identified in the extant theoretical and empirical literature of creativity and creative problem solving. Thus, the participants rated their solution on six characteristics related to the originality (i.e., innovative, unusual, original, imaginative, novel, and unique) of a solution and on six characteristics related to the effectiveness of a creative course (i.e., effective, affordable, implementable, goal-directed, feasible, and successful). Two additional characteristics namely risky and organized, which pertained to the solution originality and effectiveness respectively, were added after the second pilot administration to expand the scale in an attempt to improve the internal consistency of the scale. For each of the 16 items,
participants were directed to provide estimates of the degree to which their creative high school course meets each characteristic on a scale ranging from Not Very (0) to Very (5).

Table 3.3

*Coefficients for the Exploratory Factor Analysis with Promax Rotation for the Self-Evaluation Scale*

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Course Effectiveness</th>
<th>Course Originality</th>
</tr>
</thead>
<tbody>
<tr>
<td>Effective</td>
<td>.81</td>
<td>.04</td>
</tr>
<tr>
<td>Successful</td>
<td>.78</td>
<td>.10</td>
</tr>
<tr>
<td>Affordable</td>
<td>.74</td>
<td>-.30</td>
</tr>
<tr>
<td>Organized</td>
<td>.73</td>
<td>.10</td>
</tr>
<tr>
<td>Goal-directed</td>
<td>.69</td>
<td>.00</td>
</tr>
<tr>
<td>Implementable</td>
<td>.69</td>
<td>-.09</td>
</tr>
<tr>
<td>Feasible</td>
<td>.65</td>
<td>.04</td>
</tr>
<tr>
<td>Unique</td>
<td>.08</td>
<td>.86</td>
</tr>
<tr>
<td>Imaginative</td>
<td>-.02</td>
<td>.80</td>
</tr>
<tr>
<td>Unusual</td>
<td>-.13</td>
<td>.75</td>
</tr>
<tr>
<td>Original</td>
<td>.13</td>
<td>.68</td>
</tr>
<tr>
<td>Novel</td>
<td>.06</td>
<td>.68</td>
</tr>
<tr>
<td>Risky</td>
<td>-.40</td>
<td>.60</td>
</tr>
<tr>
<td>Innovative</td>
<td>.34</td>
<td>.56</td>
</tr>
<tr>
<td>Eigenvalues</td>
<td>6.064</td>
<td>2.452</td>
</tr>
<tr>
<td>Percentage of</td>
<td>40.581</td>
<td>14.01</td>
</tr>
<tr>
<td>Variance</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Note. Factor loadings >.4 are in bold*

In order to determine the structure of the self-evaluation questionnaire for creative solutions the data (n=103) was submitted to an exploratory factor analysis with a Principal Axis Factoring extraction and a Promax rotation. Promax rotation is a type of oblique rotation that aids the interpretation of the factor analysis results when the factors are believed to be correlated (Costello & Osborne, 2005). Given that the self-evaluations of originality and effectiveness are both factors underlying the evaluations of a
creative solution it is expected that the two factors representing self-evaluations of (a) course originality and (b) course effectiveness might be correlated.

The initial Principal Axis Factoring with a Promax rotation extracted three underlying factors with eigenvalues of 6.274, 2.584, and 1.277, which were greater than the Kaiser criterion value of 1. However, an examination of the scree plot indicated that two factors could be extracted from the data since there were two points before the break point in the data. A review of the pattern matrix indicated that the two distracters and the characteristic ‘risky’ loaded on the third factor, which was conceptually irrelevant and explained only 4.48% of the data. Given that the factor accounted for so little variance and was conceptually unexplainable, the two distracter items that loaded on the third model were removed from further analysis.

To further test the hypothesized two-factor model, a second factor analysis was conducted using a Principal Axis Factoring extraction and a Promax rotation, after the three items were removed. Two factors emerged with eigenvalues equal to 6.064 and 2.452 which explained 40.581% and 14.01% of the data. The factor intercorrelation was moderate ($r_{12}=.49$). Table 3.3 summarizes the loadings on the two factors based on the pattern matrix.

The reliability coefficient for the 7-item solution self-evaluation subscale pertaining to the effectiveness of the proposed course was $\alpha=.88$. The effectiveness subscale included seven criteria: effective, successful, affordable, organized, goal-directed, implementable, and feasible. The values of the effectiveness subscale range from 0 to 35 and the participants rated their course as moderately effective $M=26.63$ (5.38).

The reliability coefficient for the 7-item solution self-evaluation subscale pertaining to originality was $\alpha=.87$. The originality subscale included six criteria: unique, imaginative, unusual, original, novel, and innovative. The values of the originality subscale range from 0 to 35 and the participants rated their course low in terms of its originality $M=18.92$ (6.72). Both subscales had acceptable internal consistency reliability indices above the reliability criterion of .80.
Problem Scenario

The problem scenario required students to assume the role of a newly hired high school teacher who is asked by the principal to design a creative college preparatory course for a high school’s senior students in order to prepare them better for college and reduce the college dropout rate among the high school graduates. The problem solving task was originally administered by Hunter and his colleagues (2008) and has yielded acceptable interrater agreement scores (0.70-0.80) with respect to the originality and quality scores assigned to the solution (i.e., essay form) when each of the two dimensions was rated by three raters on a Likert type scale that ranged from Poor (1) to Excellent (5). Hunter et al. (2008) defined original solutions as novel and unexpected. A high quality solution was described as coherent, logical, complete, and one that meets the requirements and constraints of the task.

The problem scenario was modified in two ways for the purposes of this study. First, any descriptions or conceptualizations of a creative course were removed so that students relied on their own beliefs and applied personal definitions of a creative course. Nevertheless, the scenario emphasizes that the problem solvers need to take a creative approach in designing and teaching the course. Second, the last paragraph was modified to identify the two tasks that participants had to complete after reading the scenario. Specifically, participants were directed to identify the overall goal of their creative high school course and list and describe the specific learning activities of this course. Refer to Appendix C for the problem scenario.

Problem Solving Task

Students completed the first part of the problem solving task designed to scaffold problem solving in which they identified the overall goal of their creative high school course. Once the participants specified the overall goal they were asked to list and describe the specific learning activities of their creative high school course.

The development of a course is a relatively ill-structured and authentic task that education majors are very likely to encounter during their career as educational professionals. This problem solving task of designing a course and specifically identifying learning activities for a creative high school course is a
somewhat ill-structured task for several reasons. The task requires students to apply their own conceptualizations of creative courses and creative teaching. Moreover, it requires students to extract the important and relevant information from the scenario and identify the constraints for solving the problem.

Important information in the problem scenario included:

1. The high freshman dropout rate from college among the high school’s students (50%).
2. Freshman college students who did not drop out adopted new patterns of behavior in college.
3. Freshman college students who did not drop out felt overwhelmed and underprepared for college.

Developing a solution to the ill-structured problem required students to identify constraints such as:

1. The course will be a mandatory high school course.
2. Each class will be capped to 30 students.
3. The course has to be a creative course in which the instructor will take a creative approach in designing and teaching the course.

Further, students had to draw on their knowledge and beliefs to make judgments about the type of information, knowledge, skills, strategies, and attitudes that high school students need to acquire in order to be better prepared for the transition to college and to succeed in college. In addition, students had to design the learning activities of the course by drawing assumptions on how the parameters of the school context could impact the success of the course and establish criteria to evaluate their solution. In summary, the described approach for developing a creative high school course is typical of the problem solving process that learners adopt when they respond to problems that rank low on the continuum of problem structureness and are referred to as ill-structured.

The problem solving scenario and the task were included in the two pilot administrations of the study and were discussed during two focus groups after the administration of the first pilot study. Both the pilot administrations and the focus group provided data about the comprehensibility of the problem scenario and the directions. In general the participants found the directions clear and the scenario understandable. One modification was made to the directions to prompt students to provide a more
detailed description of the learning activities to elicit more elaborated responses. In the second pilot study and the present study participants were asked to list and describe the specific learning activities of their creative course. Students provided more descriptive and detailed responses to this modified prompt.

The focus group discussions that followed the first pilot administration were conducted to gather information about the face validity of the problem solving task. The students acknowledged the authenticity of the problem scenario as they pointed that it challenged them to provide a solution to a real life problem: the fact that high school students are not prepared for the academic, social and emotional challenges of the transition to college. Pilot study participants said that once they read the problem scenario they had to pause and reflect on what their needs were when they moved to college and what is important for a student to achieve in college. Overall, the authenticity of the problem scenario and its relevance to the participants’ recent college transition experiences seems to motivate and engage students with the task as the students agreed on the importance of designing a high school course to prepare students for college.

**Coding.** The problem solving task required participants to list and describe specific learning activities that they would include in their creative high school course to address the high rates of college drop outs among the high school’s graduates. Given that there was no extant coding scheme besides the originality and quality scoring rubrics that have been previously applied to score the essay form responses to the problem (Hunter et al., 2008), it was imperative to develop a coding scheme and establish (a) the validity of the coding scheme and (b) the reliability of the coded responses.

The researcher and an independent coder (Coder B) developed a coding guide in order to identify and summarize the types of learning activities that respondents proposed by following an iterative procedure for validating the coding scheme and developing a set of assumptions and decision rules. The second independent coder was an educational psychology graduate student with extensive experience in coding written protocols. Both coders applied a keyword content analysis approach to identify the task-
relevant units within a response that addressed the question prompt to list and describe the specific learning activities of the creative high school course.

The unit of analysis was any task-relevant unit, which represented any distinct task-relevant statement that captured potential learning activities that participants generated for their high school course. A learning activity was defined as any learning experience either enactive (i.e., through actual doing) or vicarious (i.e., students observe, listen or engaged in other ways) designed for the learners to attain an instructional goal such as the acquisition of information, knowledge, skills, abilities, attitudes and strategies. Further information about the guidelines I followed to code the responses to the problem solving task are provided in Appendix G. First, I reviewed the entire set of responses to generate an initial set of coding categories to summarize the responses to the question prompt that participants recorded. This initial review of responses indicated that participants put forward not only learning activities but also proposed assessment activities and referred to other instruction and course design elements such as materials, educational technology, and learning goals. Following, the researcher provided directions to the second coder to develop her version of the coding scheme. The directions included the problem scenario, the problem solving task, a set of coding guidelines and an example of a coded response. Then, the second coder proceeded to review the entire set of responses to independently generate a second version of the coding scheme.

During two, 2-hour discussion sessions the two independent coders analyzed, compared, and synthesized the two alternative coding schemes to generate a merged coding scheme and a set of coding guidelines with definitions, assumptions and decision rules (see Appendix E). The two coders came to agreement about two important points relevant to the merged coding scheme. First, the coding scheme should capture a broader spectrum of task-relevant units that identified not only learning activities but also assessment activities, and other instruction/course design elements (e.g., instructional materials, learning goals, educational technology, course structure, etc.). Second, a small grain size is preferable for the coding categories in order to identify meaningful differences between task-relevant units. The two
discussions resulted in a coding guide with guidelines and a merged coding scheme with two category levels (a) coding categories which was the set of categories applied in the coding of task-relevant units and (b) overarching categories which summarize the coding categories. The frequency of occurrence of each overarching category within the pool of task-relevant units ($N=359$) is presented in Table 3.4. The coders used the coding guide for an independent trial coding of the 10% of the responses, which was followed by a discussion meeting during which the coders resolved differences, refined the scheme and clarified some decision rules.

Once the coding scheme was validated, the researcher and the same graduate student coder (Coder B) used the coding guide to independently code another 20% ($n=23$) of the responses in order to estimate the intercoder agreement. For each of the responses to the problem solving task the two coders identified and coded the task-relevant units either learning activities or other instruction/course design elements based on the coding scheme. Examples for each of the coding categories in the coding scheme are provided in Appendix E.

Table 3.4

<table>
<thead>
<tr>
<th>Overarching Category</th>
<th>Frequency of Occurrence</th>
<th>Proportion of Occurrence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Discussion</td>
<td>18</td>
<td>0.050</td>
</tr>
<tr>
<td>Warm Up</td>
<td>4</td>
<td>0.011</td>
</tr>
<tr>
<td>Instructor Led</td>
<td>94</td>
<td>0.259</td>
</tr>
<tr>
<td>Problem Solving</td>
<td>6</td>
<td>0.018</td>
</tr>
<tr>
<td>Experiential Learning</td>
<td>93</td>
<td>0.259</td>
</tr>
<tr>
<td>Research</td>
<td>13</td>
<td>0.036</td>
</tr>
<tr>
<td>Writing Assignments</td>
<td>58</td>
<td>0.162</td>
</tr>
<tr>
<td>Reading Assignments</td>
<td>3</td>
<td>0.008</td>
</tr>
<tr>
<td>Classroom Assessment</td>
<td>26</td>
<td>0.072</td>
</tr>
<tr>
<td>Instruction/Course Design</td>
<td>44</td>
<td>0.125</td>
</tr>
</tbody>
</table>
The intercoder agreement for the total number of ideas was $\alpha = .79$ and for the type of code assigned to a task-relevant unit was $\alpha = .72$, which are both above the moderate criterion .70 selected for the conservative Kalpha coefficient for intercoder agreement. The two coders first resolved the disagreements that occurred in the number of task-relevant units and then proceeded to discuss the disagreements in the assignment of codes to a task-relevant unit in order to reach consensus. Three examples are presented and discussed to illustrate the coding procedure.

The first quoted example is a response by a participant [ID 2] who identified as the overall goal of the class “to prepare students to get ready for college. Teach them the importance of becoming successful people in their lives, and stress the fact that a college degree will help them reach that. The goals are to get students used to doing so much work in school that the work in college isn't anything new to them”. Six task-relevant units were identified in the following response to the prompt to list and describe specific learning activities of the creative high school course:

*I would first make sure they know how to write a good research paper. I would let them pick a topic and teach them how to do research on the topic until they have enough information [1] to write a paper [2] worthy of "C" or higher and let them keep writing until they achieve that. I would provide multiple classes on specific note taking. I would just talk for a couple days with only outlines on powerpoints and talk more in depth on the topic [3], and provide quizzes on the information that I say the stress the importance of note-taking during lectures [4]. I would bring in survey the students on what they want to do with their lives [5] and bring in interesting guest speakers for all of the different occupations that they are interested in [6]. This way the students can see what they are capable of doing with their lives and make them want to stay in school.*

According to the coding scheme the six task-relevant units that addressed the question prompt were coded as follows: *teach them how to do research on the topic* was an instance of modeling; *write a paper* was coded as an example of extended expository writing; classes in which students take notes based on the outlines on a powerpoint were coded as a note taking activity, the quizzes were coded as testing; the survey was coded as a type of diagnostic technique; and the guest speakers from a range of occupations were assigned a guest speaker code.
The second example is a coded response generated by a participant [ID 40] whose course had the overall goal to “To prepare students for the varying teaching techniques, different classes, and different lifestyle required in college”. The participant’s response is quoted below:

the students will learn time management by having several project [1] yet due at varying times [2] / writing assignments will be given in respect to more college like writing styles[3] / provide class times that are longer and varying days of the week [4] / the course shall have varying styles of teaching to introduce students to the different ways professors will be teaching within college including group work [5], lectures [6], etc. / the course will have general course material to prepare students for the various courses they will take [7].

In the above response the two coders had identified seven task-relevant units which were coded as follows based on the merged coding scheme: (a) projects in which students have to complete several projects, (b) having the projects due at varying times to promote time management was coded as course structure or schedule, (c) writing assignments were coded as unspecified writing assignment, (d) longer class time spread in varying days of the week again referred to course structure, (e) group work was coded as an academic simulation, (f) lecture was coded under the general term lecture and the last idea was coded as course materials.

A third example of a generated response to the problem solving task is the following. In this case the overall goal of the course was to “Prepare students both cognitively and organizationally for college life and courses”. Five task-relevant units emerged as the consensus valid task-relevant units during discussion among the two coders. The last two units “a course that can be structured like a college course with fewer exams and testing” and “only meet 3 days a week” were classified in the coding category course structure since the task-relevant units referred to how the proposed course would be organized.

First Semester: Fundamentals / Problem solving scenarios in groups[1] / Note taking goals and study skills / Guest speakers[2] / College visits[3] / Second Semester: Applied / College level Course- design a course that can be structured like a college course with fewer exams and testing
as opposed to a regular high school courses Only meet 3 days a week [5]: rest of the time-free study.

Scoring. The valid task-relevant units that participants recorded in response to the prompt to list and describe the specific learning activities of the creative high school course were scored for their originality and effectiveness. All valid task-relevant units (N=349) were assigned an originality and an effectiveness score. The task-relevant units that were coded as learning goals or objectives (n=10) were considered as non-valid units in response to the question prompt as they were broad statements that identified what the instructor intended for students to learn. These ten ideas were dropped from further analysis.

Originality. Originality was defined as the rareness of occurrence of a task-relevant unit within the pool of valid units generated by the participants. Among the valid task-relevant units, 315 units were classified as learning or assessment activities. Moreover, 25 participants recorded another 34 task-relevant units that were coded as instruction/course design elements and referred to aspects of instruction or course design such as materials, educational technology, and the structure of the course or the learning environment. The originality score (x) assigned to a valid task-relevant unit (i) was the rareness proportion of the specific code within the pool of (a) learning/assessment activities units or (b) instruction/course elements, depending on the nature of the task-relevant unit. For example, a task-relevant unit with the code instructor modeling occurred 55 times and its proportion of occurrence within the pool of learning/assessment activities was 55/315=0.18, and its rareness of occurrence was 1-0.18=0.82. Similarly, a task-relevant unit with the code educational technologies appeared 6 times within the pool of 34 task-relevant units of the overarching category of instruction/course design elements, thus its proportion of occurrence was 6/34=.18 and its rareness of occurrence was 1-0.18=.82.

The procedure for estimating the originality scores diverged from the traditional procedure in which an originality score is based on the statistical rarity of the response within the sample of participants (Hocevar & Michael, 1979). The ill-structured nature of the task called for a different approach in estimating the originality of the task-relevant units. In response to the task, the participants
proposed a solution comprised of several task-relevant units instead of a single answer. Specifically, it was possible that more than one task-relevant unit referred to the same type of learning activity. For example, the same participant offered two instances of practice such as practicing time management and practicing budget management skills. Because the task-relevant units generated by this participant could be assigned the same code (i.e., practice), the originality of a task-relevant unit would be overestimated if the originality score for the task-relevant unit was calculated based on the rareness of occurrence of an idea within the sample of participants. Instead, the originality score for a task-relevant unit was estimated based on the rareness of occurrence of the task-relevant unit within the pool of valid task-relevant units to account for the instances in which participants might have generated responses that were coded with the same code.

The following formula was applied to estimate the average originality score for the solution proposed by a participant ($j$): average originality $= \frac{\sum_{i=1}^{m_j} x_i}{m_j}$. The average originality score ($x$) is the sum total of the rareness proportion ($x$) for every $i$th valid task-relevant unit divided by the number of valid task-relevant units ($m$) recorded by each participant. Following the scoring guidelines of Diakidoy and Constantinou (2001) the solution originality score was computed based on the number of valid task-relevant units instead of the total number of task-relevant units to reduce the likelihood of the originality scores to be confounded with ideational fluency (i.e., total number of task-relevant units).

For the first example cited in the coding section, the formula for estimating the average originality of the proposed solution was applied as follows. The average originality score for the specific proposed solution indicates that it is highly original with respect to the other solutions in the sample:

$$x = \frac{\sum_{i=1}^{6} 0.83 + 0.94 + 0.95 + 0.94 + 0.99 + 0.98}{6} = 0.94$$

**Effectiveness.** Effectiveness was defined as the degree to which a learning or assessment activity or other instruction or course design element contributes to smooth transition and academic success in college primarily during the first two years of college. Each valid task-relevant unit was assigned an effectiveness score. Valid task-relevant units ($N=349$) included the learning and assessment activities,
and any other instruction or course design element that participants recorded as part of their course excluding any statements that identified learning goals or objectives. Effectiveness was scored on a rubric ranging from Inadequate (0) to Strong (4) effectiveness.

A learning activity or other valid task-relevant unit was considered strong when it targeted important information, knowledge, abilities, skills, or strategies for smooth transition and academic success in the first years of college and when it strongly aligned with the overall goal of the course. Responses were assigned a lower effectiveness score if they either targeted somewhat important information, knowledge, abilities, skills or strategies or were weakly aligned with the overall course goal.

The categorization of information, knowledge, abilities, skills, or strategies as important or somewhat important for smooth transition and academic success in college, was informed by the literatures on transition to emerging adulthood, and college transition and persistence, which identify factors that were found to be supportive during the transition periods (Berk, 2010; Goldbrick-Lab et al., 2007; Louie, 2007; Pritchard et al, 2007; Roe Clark, 2005). Drawing on the cognitive, social and emotional attributes identified as important factors that foster resilience and smooth transition, the following categorization was applied: (a) writing skills, study skills, note taking skills and test taking strategies but also coping strategies and interpersonal skills were categorized as important for college transition and success, (b) presentation skills, the ability to correctly cite sources, and knowledge of higher education are examples of less important factors for smooth transition and success in college.

The effectiveness score was not only determined by the importance of the information, knowledge, abilities, skills, or strategies for smooth transition and academic success but also by how well the learning activity or other instructional element was aligned with the overall goal of the course. Instructional alignment was defined as the match between learning objectives, learning activities, and assessments, and it is essential for promoting learning (Eggen & Kauchak, 2010, p. 394). A learning activity was strongly aligned with the goal of the course when it was directly relevant to the course goal. Weakly aligned learning activities were somewhat related to the course goal and there were also learning activities that did not align with the goal. The scoring rubric used to evaluate the learning activities and
other valid task-relevant units is displayed in Table 3.5. Further information about the scoring procedures applied for scoring effectiveness can be found in the scoring guide presented in Appendix G.

In order to establish the reliability of the effectiveness scores, two raters including the researcher scored 20% \((n=23)\) of the data. The second rater (Rater A) was an educational psychology graduate student with experience in coding using the content analysis approach. The rater had received a two-hour training from the researcher before independently coding 20% of the data.

Table 3.5

**Effectiveness Scoring Rubric for the Coded Task-Relevant Units**

<table>
<thead>
<tr>
<th>Score</th>
<th>Descriptor</th>
</tr>
</thead>
</table>
| **4-Strong** | The learning activity or other instruction/course design element  
- targets important information, knowledge, abilities, skills and strategies for academic success in college or smooth transition to college.  
- strongly aligns with the overall goal of the course. |
| **3-Moderate** | The learning activity or other instruction/course design element  
(weak/strong)  
- targets somewhat important information, knowledge, abilities, skills and strategies for academic success in college or smooth transition to college.  
- strongly aligns with the overall goal of the course.  
OR  
(strong/weak)  
- targets important information, knowledge, abilities, skills and strategies for academic success in college or smooth transition to college.  
- weakly aligns with the overall goal of the course. |
| **2-Weak** | The learning activity or other instruction/course design element  
(weak/weak)  
- targets somewhat important information, knowledge, abilities, skills and strategies for academic success in college or smooth transition to college.  
- weakly aligns with the overall goal of the course. |
| **1-Insufficient** | The learning activity or other instruction/course design element  
(weak/inad)  
- targets somewhat important information, knowledge, abilities, skills and strategies for academic success in college or smooth transition to college.  
- does not align with the overall goal of the course.  
OR  
(inad/weak)  
- does not target information, knowledge, abilities, skills and strategies for academic success in college or smooth transition to college.  
- weakly aligns with the overall goal of the course. |
| **0-Inadequate** | The learning activity or other instruction/course design element  
(inad/inad)  
- does not target information, knowledge, abilities, skills and strategies for academic success in college or smooth transition to college.  
- does not align with the overall goal of the course. |
During the training the researcher presented the problem solving task, the guidelines for scoring and explained the different levels of the scoring rubric using examples drawn from the pilot data set. Next the two raters independently scored another three subsets of cases that were drawn from the pilot data set (30%) and discussed their assigned scores. A modified scoring guide with a set of guidelines, assumptions, and decision making rules was generated based on the discussion of the scored pilot data.

Following the training the two raters proceeded to independently score 20% \( n=23 \) of the data. The subset of cases selected to score for effectiveness were the same cases used in the previous inter coder agreement process executed to establish the validity of the coding scheme for the type of activities recorded, so that consensus task-relevant units were scored for effectiveness. The initial inter-rater agreement was \( \alpha=.60 \), which is lower than the selected criterion of .70. The two raters met to discuss their assigned scores and resolve any disagreements. Disagreements were due to two main reasons: (a) differential scoring when the learning activity was general (e.g., guest speaker or interview) and could provide both important and somewhat important information for success and smooth transition to college and (b) differential scoring when the task-relevant unit described how the instructor would structure and organize the course or a learning activity to simulate the college experience or environment. For both of these cases the two raters specified further guidelines in the scoring guide.

A second round of scoring followed with another subset of 10% of the data \( n=11 \). The inter-rater agreement reached an acceptable level \( \alpha=.82 \). The raters disagreed in the effectiveness scoring of only five task-relevant units from a total of 39 units scored. The disagreements were resolved in discussion to determine the consensus effectiveness score.

Once all valid task-relevant units were scored for their effectiveness an average effectiveness score for the solution was estimated based on the effectiveness score assigned to each valid task-relevant unit by applying the following formula: average effectiveness = \[ \frac{\sum_{i=1}^{m_j} y_i}{m_j} \]. The average effectiveness score \( y \) for each participant \( j \) is the sum total of the effectiveness score \( y \) for every \( t^{th} \) valid task-relevant
unit that each participant generated divided by the number of valid units \( (m) \) proposed by each participant \((j)\).

For the first cited example in which the student identified as the goal of the high school course to “teach them the importance of becoming successful people in their lives, and stress the fact that a college degree will help them reach that. The goals are to get students used to doing so much work in school that the work in college isn’t anything new to them.” The learning activities that the student proposed were designed to promote the various knowledge, skills, abilities, and strategies:

1. modeling of how to do research on the topic to develop students’ research skills
2. extended expository writing in the form of papers to develop writing skills
3. note taking activity based on the outlines on a powerpoint to promote note taking skills
4. testing in the form of quizzes to practice test taking strategies
5. surveying as a type of diagnostic to support career decision making
6. guest speakers from a range of occupations were assigned a guest speaker code to support career decision making

The task-relevant units varied in their importance for smooth transition and success in college as writing and note taking skills and test taking strategies are classified as important and the research skills and career decision making as somewhat important. The task-relevant units \([1, 5, 6]\) were assigned a moderate effectiveness score (i.e., 3) as they promoted somewhat important skills and abilities for transition and academic success in college, and task-relevant units \([2, 3, 4]\) were assigned a strong effectiveness score (i.e., 4) as they developed important skills for academic success in college. Thus, average effectiveness was estimated as follows:

\[
\text{average effectiveness} = \frac{\sum_{i=1}^{6} 3 + 4 + 4 + 4 + 3 + 3}{6} = 3.5
\]

**Reflective Tasks**

In both experimental conditions, a reflective task followed the problem solving task. Reflection operates through a careful reexamination and evaluation of experience, beliefs, and knowledge (Kember,
McKay, Sinclair & Wong, 2008). Further, a task that engages students in reflective thinking involves them in reasoning that is focused on deciding what to believe or do, and drawing inferences or conclusions (Ennis, 1987). Students completed one of two tasks that engaged them in reflective thinking about the creative course they proposed based on the condition to which they were randomly assigned. In the Explanation Condition they provided an explanation of their creative high school course to the school board members. By comparison, participants in the Argumentation Condition argued with specific reasons about their creative high school course and generated corresponding potential objections of the school board members about the course. Fifty-three students were assigned to the Explanation condition and 50 participants were assigned to the Argumentation condition.

Explanation Task. Participants who responded to the explanatory reflective task were directed to explain further their creative high school course to the school board. According to Wiley and Voss (1999), an explanation instruction prompt represents a more causal account than a narrative or a summary task and encourages students to be somewhat more reflective about an idea or solution and develop a causal model to describe why they proposed the specific high school course. The directions for the explanatory reflective task prompted the participants to “provide an explanation of their creative course to the school board members.”

Argumentation Vee Diagram. Participants who responded to the argumentation task were presented with a graphic organizer referred to as the Argumentation Vee Diagram (AVD). The diagram was originally developed by Novak and Gowing (1984) to structure science investigations and adapted by Nussbaum (2008) for use as a component of an argumentation intervention. Argumentation diagrams represent a type of graphic organizer that can enhance reflective thinking as it allows exploration and integration of various sides of an issue by making the arguments-counterarguments more salient (Nussbaum, 2008). The AVD was modified for two reasons: (a) to adapt it to the online administration of the study and (b) to constrain the participants to the use of the same integration strategy namely weighing a reason with the corresponding objection to determine which is stronger. The final form of the AVD for
the online administration emerged after the two pilot study investigations were conducted to determine its comprehensibility and gather evidence of process validity.

Across the two pilot studies, ten participants generated reasons, in essence arguments for proposing their course along with objections or possible challenges that the board members may raise about their creative course. Student-generated reasons included referencing the challenges of the transition to college, providing a rationale for the course, explaining the unique nature of the course, and arguing about the content of the course and reasons why the course will be successful. Among the potential objections that participants proposed in the pilot studies included statements why the course might not be popular, successful or adoptable by high school students. Participants counterargued about conducting a needs assessment to determine whether such a course is necessary and to explore the available and required resources for the course.

In conclusion, the results of the pilot investigations indicated that participants followed the directions, generated arguments to support their course and projected counterarguments in opposition to the proposed creative high school course. However, there were two limitations with the format of the AVD as it was administered in the first pilot study: (a) the diagram did not require a 1-1 correspondence between a reason and an objection, and (b) the integrate question prompt did not require students to engage in a behavioral task to provide a response.

Thus, in the second pilot study participants were directed to reread their reasons and corresponding objections and indicate with a √ which is the stronger in order to apply the weighing integration strategy. Overall, based on the two pilot studies, participants’ responses, and the focus group discussion indicated that the directions were comprehensible and participants were able to complete the diagram by recording reasons and objections. The revised structure of the AVD administered in the present study ensured correspondence and integration across reasons and objections. Figure 3.1 displays the argumentation task as it was presented online in the current study.
Participants in the dissertation study were directed to write in two columns below the diagram: on the left column they were asked to write reasons why the proposed course is a creative high school course and on the right column they generated corresponding potential objections that the high school board members might raise. Participants were given guidelines on how to complete the diagram and were prompted to integrate each reason with the corresponding objection. Specifically the integration prompt instructed them to reread their reasons and corresponding objections. For each pair participants were asked to select the reason or corresponding objection that was stronger. Participants could record up to five reasons and objections to their creative high school course. Five pairs of reasons/objections were proposed by 13 participants (26%) and a set of four reasons and objections was recorded by four students (8%). The 20% of the students (n=10) proposed three reasons and objections and 16 students (32%)
recorded two sets of reasons and objections. Finally, five students (10%) put forward only one pair of reasons and objections. Two students identified only reasons but no objections.

**Research Design**

A randomized, single factor between-groups design was applied in this online experimental study with two comparison groups. The independent factor had two levels which represent the two different reflective tasks administered post problem solving to evoke reflective thinking about the proposed creative course. The experimental group (argumentation condition) completed an Argumentation Vee Diagram (AVD) for which the participants generated reasons and corresponding potential objections that the school board members may raise and for each pair participants indicated which is the stronger. The comparison group (Explanation condition) provided a more elaborate explanation of their proposed creative course to the school board members.

**Procedures**

Students were given a five day window to access the link, which was posted on the course management system (ANGEL) in order to complete the study. Students logged into the online survey system (Qualtrics) by entering their webmail ID, which was then replaced by a random number to ensure the confidentiality of the data. Participants were randomly assigned by the Qualtrics survey software to either the Explanation or Argumentation condition.

![Diagram showing the flow of the online administrated study.]

*Figure 3.2. The flow of the online administrated study.*
Initially respondents filled in the demographic cover page and the two divergent thinking tasks, which were counterbalanced to account for order effects. Following students completed the questionnaire targeting beliefs about creative courses and the Need for Cognition Scale. All of the items on the belief questionnaire and the Need for Cognition Scale were presented in a random order. Next, students read the problem scenario and (a) identified the overall goal of their creative high school course and (b) listed and described the specific learning activities they would include in their course. Students were allowed to refer back to the problem scenario while they were specifying the course goal and developing the learning activities.

Depending on their assigned condition, participants responded to a different reflective task: they either provided an explanation about their proposed course or completed an argumentation diagram about the strengths and limitations of the course. Students in the argumentation condition listed reason(s) and corresponding potential objections that the school board members might raise for their proposed creative course. To comply with the structure of the Argumentation Vee Diagrams (AVD) as it was used by Nussbaum (2008), the students in the argumentation condition were prompted to integrate their reasons and objections by weighing their reasons and objections to indicate whether a reason or a corresponding objection is stronger.

Finally, all participants responded to the solution self-evaluation questionnaire in which they provided estimates of the extent to which their creative course meets a number of descriptors that are characteristic of creative solutions. All of the items on the solution self-evaluation questionnaire were randomized. Figure 3.2 shows the flow of the study as it was designed and administered online. A list of all the variables entered for data analyses in the present study with basic descriptive statistics such as a variable’s mean, standard deviation, possible and actual range, and the internal consistency coefficient when a composite was formed are included in Appendix H.
Data Analyses

The present study addressed the following research questions:

1. What is the content of creative solutions proposed to a course design problem?
2. How do students conceptualize creative outcomes?
3. How do individual differences in divergent thinking, need for cognition, relevant coursework in curriculum and instructional design, and beliefs about creative outcomes impact the creativity of a solution with respect to its (a) originality and (b) effectiveness?
4. To what extent does an argumentation diagram support the self-evaluation of a solution?

The first research question examines the content of the creative solutions that participants proposed to the course design problem and specifically the type of the learning activities and other task-relevant responses that participants proposed to the problem solving task. Descriptive statistics including frequencies and percentages are presented to summarize the specific learning activities and other instruction/course design elements that participants suggested.

The second research question explored how the participants conceptualized creative outcomes and specifically what they perceive to be the characteristics of creative courses. Descriptive statistics summarize information about participants’ beliefs about the characteristics of creative courses based on a set of adjectives that describe creative outcomes in terms of their originality and effectiveness.

To address the third research question pertaining to how individual difference factors predict the creativity of a solution in terms of the average originality and effectiveness of the learning activities that participants generated, two separate multiple regression models with five predictors were conducted since there was no significant correlation between the two outcome variables of average originality and average effectiveness. The following variables were entered as predictors: divergent thinking (I) and divergent thinking (II), need for cognition, beliefs about creative courses and relevant coursework to curriculum and instructional design. To determine the effect of individual difference variables on the average originality of a solution, an ordinal regression was conducted due to the violation of the normality of residuals.
assumption. The effect of individual difference predictors on the average effectiveness of a solution was
determined by a multiple linear regression model since the assumptions were met.

A multiple multivariate regression analysis using the General Linear Model approach was
conducted to address the fourth research question. This analysis determined the comparative effect of an
Argumentation and an Explanation task on students’ self-evaluations of their solution when students’
beliefs about creative solutions, relevant coursework, need for cognition, and the average effectiveness
and originality scores assigned to their solution were entered as predictors. The fixed factor in the model
was the condition determined by the type of reflective task (i.e., Explanation or Argumentation). The
outcome variables were the sum of the originality and effectiveness self-evaluations of the creative high
school course that participants proposed.
CHAPTER 4

Results and Discussion

The purpose of the study was to explore creative problem solving performance and examine ways to support reflective self-evaluations of the proposed creative solutions. Using a computerized interface, participants completed a set of individual difference measures and then proceeded to read the problem scenario in which they assumed the role of a newly hired high school teacher who is asked by the principal to design a creative college preparatory course for the high school senior students. The purpose of the high school course would be to reduce the college dropout rate among the high school graduates and better prepare them for the transition to college. The participants identified the overall goal of the high school course and generated specific learning activities for the course.

To examine the effects of argumentation on self-evaluation, a group of participants completed an Argumentation Vee Diagram (AVD) and then evaluated their course with respect to a set of characteristics descriptive of creative outcomes. A second group of participants responded to an explanation prompt before they evaluated their proposed high school course. Assumedly, if the argumentation diagram promotes more reflective critical thinking, then for students who engaged in argumentation, the average originality and effectiveness score of their solution is predictive of their self-evaluations of the creative course.

In this results and discussion chapter I will first present and discuss the content of the creative solutions that participants proposed to the problem scenario. Second, I will address the four research questions that guided the execution of this study through a presentation and discussion of the descriptive statistics and the statistical models organized in four sections based on the research questions that guided this study: (a) Content of creative solutions; (b) Conceptualizations of creative outcomes; (b) Predictors of creative solutions, and (c) The effectiveness of the argumentation diagram.

The Content of the Creative Solutions to the Course Design Problem

The problem scenario required participants to design a creative course to address the high college dropout rate among the high school graduates and better prepare them for the transition to college.
Participants were asked to list and describe specific learning activities that they would implement in their course. As it was explained in the Methods chapter the learning activities were scored for their originality and effectiveness, and an *average originality* and *effectiveness* score was estimated for each course that participants proposed as a potential solution to the problem. In this section, I summarize and discuss the content of participants’ proposed creative solutions with respect to the overarching categories of learning activities and the more specific coding categories based on which the originality and effectiveness scores were estimated for each learning activity.

The learning activities that participants suggested as components of their creative high school course ranged on the direct to indirect instruction continuum. The frequency of occurrence of each overarching category of learning activities within the pool of valid task-relevant units (N=349) is presented in Table 4.1.

Table 4.1

*Frequency of Occurrence of Overarching Categories within Valid Task-Relevant Units (N=349)*

<table>
<thead>
<tr>
<th>Overarching Category</th>
<th>Frequency of Occurrence</th>
<th>Percentage of Occurrence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Discussion</td>
<td>18</td>
<td>5.16</td>
</tr>
<tr>
<td>Warm Up</td>
<td>4</td>
<td>1.15</td>
</tr>
<tr>
<td>Instructor Led</td>
<td>94</td>
<td>26.93</td>
</tr>
<tr>
<td>Problem Solving</td>
<td>6</td>
<td>1.72</td>
</tr>
<tr>
<td>Experiential Learning</td>
<td>93</td>
<td>26.65</td>
</tr>
<tr>
<td>Research</td>
<td>13</td>
<td>3.72</td>
</tr>
<tr>
<td>Writing Assignments</td>
<td>58</td>
<td>16.62</td>
</tr>
<tr>
<td>Reading Assignments</td>
<td>3</td>
<td>0.86</td>
</tr>
<tr>
<td>Classroom Assessment</td>
<td>26</td>
<td>7.45</td>
</tr>
<tr>
<td>Instruction/Course Design</td>
<td>34</td>
<td>9.74</td>
</tr>
</tbody>
</table>

Among the most widely referenced learning activities within the pool of valid task-relevant units generated by the respondents were those in which the instructor or another more experienced individual
(e.g., guest speaker) was responsible for providing instructional support such as presenting content and sharing experiences. Equally popular were activities that were based on experiential learning, such as simulations, fieldtrips, and student presentations. Other learning activities included writing and reading assignments, discussions including student-centered discussions, debates, and discussions with experts. Moreover, participants identified research activities, for example searching information about an academic topic, and searching about potential careers and colleges, and learning activities based on problem solving.

Some participants ($n_1=20; 19.4\%$) included classroom assessments such as formative, summative, and diagnostic assessments in their proposed learning activities. Several students ($n_2=25; 24.3\%$) suggested other instructional or course design elements such as materials and educational technologies. It is possible that these students had interpreted the prompt more broadly than intended such that they provided ideas about how they would organize the course and plan instruction to attain the goals of the creative course. A more detailed discussion of the specific learning activities that participants listed in response to the question prompt requiring them to list examples of specific learning activities of their course is provided below.

**Summary of the Specific Learning Activities.** The learning activities that students proposed ranged from teacher-directed to more student-centered. The majority of the activities that participants proposed were represented in the overarching category *instructor led* that included activities for which the instructor or another more expert individual was in charge of instruction and was the main communicator of knowledge. The instructor led category included activities such as lecturing, modeling, scaffolding, and the implementation of workshops. The learning activities within the instructor led category are presented in Table 4.2, along with the number of participants who listed the specific learning activity and the frequency of occurrence of each activity in the pool of valid idea units.

Lecturing was either informational or reflective as the instructor either presented information or shared personal experiences. Modeling referred to the instances in which the instructor modeled either a
cognitive process or task (e.g., how to read, how to take notes) or occasions in which other models were
used in the form of multimedia such as a video or a chart.

Table 4.2

Number of Participants and Frequency of Occurrence of Instructor Led Activities.

<table>
<thead>
<tr>
<th>Type of Instructor Led Activities</th>
<th>Participants n=103</th>
<th>Frequency f</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lecture</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Informational</td>
<td>16</td>
<td>21</td>
</tr>
<tr>
<td>Reflective</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>General term</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Guest Speakers</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Modeling</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Instructor</td>
<td>34</td>
<td>55</td>
</tr>
<tr>
<td>Other Models</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Scaffolding</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Workshops</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

Experiential learning was the second major category and it was comprised of a variety of experiential learning activities such as practice opportunities for a specific, discernible skill, simulations of academic or everyday life situations in college, fieldtrips, projects, student presentations, games, experiments, and role-playing. The number of participants that identified each activity and the frequency of occurrence of the experiential learning activities in the pool of valid idea units are presented in Table 4.3. Simulations were the most frequently referenced coding category within the experiential learning activities. Several participants (n= 18, 17.5%) developed learning activities in which they simulated academic aspects of college life such as study groups, team building activities, think-pair-share situations, and scheduling courses.

In addition, some participants designed (n= 8, 7.8%) simulations of everyday life situations, for example, finding classrooms using a campus map and setting up school-like environments such as a
college building with dorms and study areas; putting students in different situations while completing homework such as with loud music on the background.

Table 4.3

*Number of Participants and Frequency of Occurrence of Experiential Learning Activities.*

<table>
<thead>
<tr>
<th>Type of Experiential Learning</th>
<th>Participants</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Practice</td>
<td>11</td>
<td>20</td>
</tr>
<tr>
<td>Simulations</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Academic/Career</td>
<td>18</td>
<td>18</td>
</tr>
<tr>
<td>Everyday Life</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>Fieldtrips</td>
<td>9</td>
<td>9</td>
</tr>
<tr>
<td>Projects</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>Student Presentations</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>Games</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Experiments</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Role Play</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Classroom Observations</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Campus Stay</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Extra Curricular Activities</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Community-Based Learning</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>General</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

The several types of experiential learning activities that participants proposed especially the opportunities for practice and the simulations but also additional student-centered activities, which involved problem solving and decision making, indicate that participants consider that active learning, which characterizes experiential activities and other student-centered activities (e.g., problem solving, decision making) to be an important instructional component of a creative college preparatory high school course.

Writing assignments was another significant category that summarized proposed learning activities in participants’ creative high school courses. The specific writing assignments that participants
forwarded are summarized based on the genre of writing and they include expository, persuasive, journals, personal writing (e.g., resume) and creative writing. Expository writing was the most popular form of writing and it was either extended, for example, research papers and essays or brief including summaries and reports. Some participants identified forms of writing in which students attempted to summarize and organize information by taking notes \((n=15, 14.6\%)\) or by filling in an organizational aid \((n=9, 8.7\%)\).

Table 4.4

*Number of Participants and Frequency of Occurrence of Writing Activities.*

<table>
<thead>
<tr>
<th>Writing Assignment</th>
<th>Participants</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Expository</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Extended</td>
<td>18</td>
<td>19</td>
</tr>
<tr>
<td>Brief</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Persuasive</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Journals</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>Personal</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Creative</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Organizational Aid</td>
<td>9</td>
<td>10</td>
</tr>
<tr>
<td>Note Taking</td>
<td>15</td>
<td>15</td>
</tr>
</tbody>
</table>

Finally, one student did not specify the type of writing assignment as the statement was general stating that the course would include various types of writing assignments. The breadth of writing activities listed by the participants illustrates the perceived importance of writing skills across various genres for academic success in college. The number of participants that identified each writing activity and the frequency of occurrence of each activity in the pool of valid idea units are presented in Table 4.4.

Reading assignments were not perceived as important as writing assignments as only three individuals listed a learning activity based on reading either textbooks or other types of books (e.g., contemporary literature). In addition, two participants listed a note-taking activity in which students were
responsible to take notes on a “college reading.” Given that reading for learning is fundamental in higher education it was unexpected that so few students recognized the significance of reading assignments. However, most of the reading typically is completed outside the classroom, which may explain that so few reading assignments were reported as learning activities of the college preparatory course.

For several students (n=20, 19.4%) classroom assessment was an important component of the creative high-school course. Diagnostic assessments such as surveys, formative classroom assessments in the form of peer-reviews, self-evaluations, and homework assignments but also summative assessments, for example, midterms and finals were some types of the classroom assessments that students identified. Refer to Table 4.5 for the number of participants who recorded each type of classroom assessment activity and the frequency of occurrence of each activity in the pool of valid idea units.

Table 4.5

<table>
<thead>
<tr>
<th>Classroom Assessments</th>
<th>Participants</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diagnostics</td>
<td>n=103</td>
<td></td>
</tr>
<tr>
<td>Surveys</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Formative</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Homework</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Self-Evaluation</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Peer-Review</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Summative</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tests</td>
<td>14</td>
<td>18</td>
</tr>
</tbody>
</table>

Other Instruction and Course Design Elements. Finally, several students provided ideas beyond the learning activities of their course that included information about the organization of the course and specified various instructional design components. These idea units were also considered valid ideas as they were aligned with the overarching task the way it was presented in the problem.
scenario, which was to design a creative high school course to reduce the dropout rates of the high school graduates.

Table 4.6

*Number of Participants and Frequency of Occurrence of Instruction and Course Design Elements.*

<table>
<thead>
<tr>
<th>Instruction &amp; Course Design</th>
<th>Participants</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Materials</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Educational Technologies</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>Syllabus</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Course Structure</td>
<td>15</td>
<td>19</td>
</tr>
<tr>
<td>Learning Environment</td>
<td>2</td>
<td>2</td>
</tr>
</tbody>
</table>

The set of instructional and course design elements that students identified are shown in Table 4.6. Participants referred to course materials (e.g., power-point slides, general course material) and educational technologies (e.g., power point) that they would incorporate in their course. The range of instructional technologies was constrained to power-point presentations. This finding is unexpected and given that nearly two thirds of the participants were education majors they were expected to be more familiar with instructional technologies since teacher preparation programs incorporate in their curriculum at least one instructional technology course.

A few students mentioned that they would develop a syllabus for the course; also they would conduct the class based on the syllabus, which they would distribute in the first day of class. Several participants (n=15, 14.6%) elaborated on the organization of the course, the course assignments, and the assessments. For example, participants specified that the course would be optional, with longer class periods a few times a week, with required and optional assignments that have to be completed within a specific time period, policies for missed assignments, and with fewer testing opportunities. The instruction and course design ideas pointed to the different structure of the college course but also the demands for more self-directed learning and self-regulation to be able to meet course requirements.
Finally, only two students discussed the importance of the classroom climate by referring to the need to create a learning environment that is supportive and encouraging in order to motivate students for the transition to college.

In summary, participants proposed a variety of learning activities that ranged on the continuum of direct to more indirect instructional strategies. This was evident in the finding that instructor led learning activities such as lecturing and modeling and experiential learning activities were the two major overarching categories that summarized most of the specific proposed learning activities. In addition, participants acknowledged the importance of assessment activities as they included different types of assessments such as diagnostic, formative and summative assessments. Finally, a few participants considered other elements of course design in their solutions such as educational technologies, strategies to promote better course structure and a positive learning environment.

**Originality and Effectiveness of Creative Solutions.** As explained in the methods chapter each learning and assessment activity and any course and instruction design element (i.e., valid task-relevant units) that participants described as components of their course was scored for its originality and effectiveness. On average, participants generated $M=3.39$ (1.77) valid task-relevant units. The average originality of a solution is calculated as a proportion and it was operationalized as the sum total of the rareness of occurrence of a valid unit in the pool of valid task-relevant units generated by the participants divided by the number of valid task-relevant units each participant recorded. Similarly, the average effectiveness of a solution ranged from 0 to 4 and it was operationalized as the sum total of the effectiveness score assigned to all task-relevant units divided by the number of valid task-relevant units that each participant generated. The average originality score of the solutions that participants proposed was high $M=0.90$ (0.09) and the average effectiveness was moderate $M=3.23$ (0.59).

**Conceptualizations of Creative Outcomes**

The second research question explored students’ conceptualizations of creative outcomes as they were manifested in their ratings of the characteristics of creative courses on the creative course beliefs questionnaire. The participants rated 28 statements on a 5-point Likert scale ranging from *Not Very* (0) to
Very Much (5) of which 12 items pertained to descriptors of creative solutions derived from the literatures of creativity and problem solving and the rest were distracters. Means and standard deviations of the items on the beliefs questionnaire are presented in Table 4.7. Each participant was assigned a composite score which ranged from 0 to 45. The composite score was calculated based on the sum of 9 of the 12 descriptors of creative outcomes included in the creative course beliefs scale. Higher scores indicate beliefs that are in alignment with the characteristics of creative outcomes as they are identified in the literature. The mean score on this scale was $M=26.89 (7.29)$, which illustrates that participants’ conceptualizations are somewhat aligned with the characteristics of creative outcomes.

Table 4.7

Means and Standard Deviations For the Belief Items (n=103)

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>$M$</th>
<th>$SD$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feasible</td>
<td>3.98</td>
<td>1.24</td>
</tr>
<tr>
<td>Effective</td>
<td>3.42</td>
<td>1.04</td>
</tr>
<tr>
<td>Innovative</td>
<td>3.25</td>
<td>1.21</td>
</tr>
<tr>
<td>Successful</td>
<td>3.23</td>
<td>1.12</td>
</tr>
<tr>
<td>Imaginative</td>
<td>3.02</td>
<td>1.05</td>
</tr>
<tr>
<td>Unique</td>
<td>2.86</td>
<td>1.27</td>
</tr>
<tr>
<td>Implementable</td>
<td>2.82</td>
<td>1.10</td>
</tr>
<tr>
<td>Original</td>
<td>2.70</td>
<td>1.22</td>
</tr>
<tr>
<td>Novel</td>
<td>2.59</td>
<td>1.13</td>
</tr>
</tbody>
</table>

Overall, students rated high characteristics relevant to the effectiveness of a creative course such as the extent to which the course is feasible $M=3.98 (1.24)$, effective $M=3.42 (1.04)$, and successful $M=3.23 (1.12)$ but also acknowledged that creative courses are innovative $M=3.25 (1.21)$ and imaginative $M=3.02 (1.05)$. Moreover, a majority of students judged feasibility as an important characteristic of creative courses. While in the research of beliefs about creativity, originality has been documented as the primary descriptor of creativity, the majority of the students conceptualized a creative course as feasible possibly due to the constraints and realities of schooling (Aljughaiman & Reynolds, 2002; Diakidoy &
Courses that are implemented in schools have to be feasible and effective but also innovative.

**Predictors of Creative Solutions**

The third research question targeted the extent to which individual variables predict the creativity of a solution with respect to the average originality and the average effectiveness of the learning activities that participants generated. Specifically, the third research question inquired about the effect of individual differences in divergent thinking, need for cognition, beliefs about creative outcomes and the impact of relevant coursework (i.e., prior knowledge) on the creativity of a solution. A summary and discussion of the descriptive statistics of the predictor variables (see Table 4.8) is followed by the presentation of the regression models that significantly predicted the creativity of a proposed solution with respect to the average originality and effectiveness of a solution.

Table 4.8

**Means and Standard Deviations of Predictors of Creative Solutions**

<table>
<thead>
<tr>
<th>Variables</th>
<th>M</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Divergent Thinking (I)</td>
<td>6.11</td>
<td>2.42</td>
</tr>
<tr>
<td>Divergent Thinking (II)</td>
<td>5.52</td>
<td>2.22</td>
</tr>
<tr>
<td>Need for Cognition</td>
<td>48.47</td>
<td>10.46</td>
</tr>
<tr>
<td>Beliefs</td>
<td>26.89</td>
<td>7.29</td>
</tr>
<tr>
<td>Relevant Coursework</td>
<td>1.59</td>
<td>.93</td>
</tr>
</tbody>
</table>

An overview of table indicates that on average participants performed relatively similarly in the two divergent thinking tasks and there was considerable variability in their responses. More variability between participants was evident in their need for cognition, which on average was low to moderate on a scale that ranged from 0-90. Moreover, participants’ beliefs about creative outcomes based on their ratings of the characteristics of creative courses indicates that participants’ beliefs are somewhat aligned with the characteristics of creative outcomes as they are conceptualized in the literature. Finally, participants’ prior knowledge with respect to the relevant coursework they completed in curriculum and instructional design was limited as the majority of the participants reported that they enrolled in one
course (64%, $n=66$), some participants reported two (19%, $n=20$) or three courses (11%, $n=11$), five reported four courses and only one participant listed five courses. The variables summarized in Table 4.8 were entered as predictors in two separate regression models to explore which variables significantly predict the creativity of a solution with respect to its average originality and effectiveness. Two separate multiple regression models with five predictors were conducted since there was no significant correlation between the two outcome variables of average originality and average effectiveness ($r=.07$, $p=.5$).

**Predictors of Solution Originality.** A multiple linear regression based on Ordinary Least Squares (OLS) estimation method was not possible to be performed to estimate the effect of individual difference variables on the average originality of a solution due to the violation of the assumption of normally distributed residual error. As shown in the P-P plot of the standardized residuals the points show significant departure from normality. Given that the sample is relatively small ($n=103$) the violation of the normality of residuals assumptions could lead to invalid t-tests for the coefficients (Kutner, Nachtsheim, Neter, & Li, 2005). Moreover, when a multiple linear regression was conducted with five predictors including divergent thinking (I, II), beliefs about creative courses, need for cognition, and relevant coursework in curriculum and instructional design, the model was not significant ($F_{(5,97)}=1.03$, $p=.40$) and it explained a very small amount of variance ($R^2=.05$).

![Figure 4.1. Normal P-P Plot of Regression Standardized Residual.](image)

In an attempt to overcome the violation of the normality assumption three transformations of the dependent variable were performed including square, log, and squared root, which did not significantly
improve the distribution of the residuals. Due to the violation of the assumption of the normality of the residuals the dependent variable was transformed into an ordinal dependent variable with three levels and an ordinal regression was conducted to estimate the predictors of solution originality. The new ordinal solution originality variable had three levels: (a) low originality ($x < .85; n_1 = 21$), moderate originality ($0.85 \leq x \leq 0.95; n_2 = 38$), and high originality ($x > 0.95; n_3 = 44$). The range for the three ordinal categories was determined based on the distribution of the average originality scores in the sample.

Ordinal logistic regression models the cumulative probabilities $P(Y_i \leq 1)$ rather than the specific category probabilities $P(Y_i = j)$ as in the case of nominal logistic regression and it yields a more parsimonious, more powerful and easier to interpret model (Kutner, et al., 2005). Thus, the ordinal regression model was used to determine the cumulative odds ratio of proposing a solution of high originality. More analytically, this ordinal regression models the cumulative odds ratio of generating (a) a solution of low originality $\ln(\text{prob}(1)/\text{prob}(>1))$ instead of a moderate or highly original solution, and (b) a solution of low or moderate originality instead of a highly original solution $\ln(\text{prob}(\leq 2)/\text{prob}(>2))$.

Five predictors were entered in the ordinal regression model including divergent thinking (I, II), beliefs about creative courses, need for cognition, and relevant coursework to curriculum and instruction that participants enrolled in. The default ordinal regression model based on a logit link function was selected. Initially both indices of divergent thinking based on participants’ scores on the two divergent thinking tasks were entered in the ordinal regression equation as covariates. However, one of the divergent thinking indices was removed as the initial ordinal regression model was non-significant. The model was fitted again after excluding the first divergent thinking index and the parallel lines assumption was examined.

**Assumption.** The parallel lines assumption also known as the proportional odds assumption needs to hold for a well-fitting ordinal regression model. The assumption is met when the slope coefficients (i.e., location parameters) of the predictor variables are equal for each level of the dependent variables. The assumption of parallel lines was met since the test of parallel lines had a non-significant p-value ($p = .68$) and the null hypothesis stating that the slope coefficients are the same across the levels of
the response variable was retained. Given that the assumption is met the fit of the full regression model was examined.

The ordinal regression model of average solution originality is a well fitting model. Specifically, the full model was significantly different from the intercept only model as the \(-2\) Log Likelihood values for the two models differed significantly (\(-2\)LL=206.96, \(\chi^2(4) =10.46, p=0.03\)). However, the effect size for the regression model of average solution originality was weak (Nagelkerke's \(R^2=.11\)).

An overview of the parameter estimates suggests that divergent thinking and relevant coursework are the two predictors that determine the likelihood of generating a solution that is high in originality. Specifically, in ordinal regression each slope parameter is interpreted as the change in the cumulative odds ratio for a unit change in its associated predictor (Kutner et al., 2005, p. 617). Table 4.9 presents the estimated coefficients for the thresholds (intercepts), the slopes of the predictor variables (i.e., location parameters), their significance and the corresponding confidence intervals.

As it is indicated by the parameter estimates, as divergent thinking ability increases the likelihood of generating a solution high in originality also increases. Specifically, for each unit increase in divergent thinking participants have lower cumulative odds of developing a solution of low or moderate originality by a factor of .84 [i.e., \(\exp(-0.18)\)] based on the computation formula suggested by Garson, 2011. That is, participants higher in divergent thinking are more likely to propose a solution high in originality.

Table 4.9

<table>
<thead>
<tr>
<th>Predictors of Solution Originality</th>
<th>Estimate</th>
<th>Wald</th>
<th>(p)</th>
<th>Confidence Intervals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Threshold</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low</td>
<td>-1.041</td>
<td>0.85</td>
<td>.36</td>
<td>[-3.26, 1.17]</td>
</tr>
<tr>
<td>Medium</td>
<td>.759</td>
<td>0.45</td>
<td>.50</td>
<td>[-1.45, 2.97]</td>
</tr>
<tr>
<td>Parameter</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Divergent Thinking (II)</td>
<td>0.18*</td>
<td>4.37</td>
<td>.04</td>
<td>[0.01, 0.36]</td>
</tr>
<tr>
<td>Beliefs</td>
<td>0.37</td>
<td>1.86</td>
<td>.17</td>
<td>[-0.02, 0.09]</td>
</tr>
<tr>
<td>Relevant Coursework</td>
<td>-0.51*</td>
<td>5.52</td>
<td>.02</td>
<td>[-0.93,-0.08]</td>
</tr>
<tr>
<td>Need for Cognition</td>
<td>-0.02</td>
<td>0.69</td>
<td>.41</td>
<td>[-0.05, 0.02]</td>
</tr>
</tbody>
</table>

*\(p<.05\)
Participants with higher relevant coursework are less likely to propose a solution high in originality. For each additional course relevant to curriculum and instructional design participants have greater odds of producing a solution of low or moderate originality by a factor of 1.67 [i.e., \( \exp(-0.51) \)]. Beliefs about creative courses that are aligned more with the characteristics of creative outcomes increased the likelihood of a highly original solution but the effect of this predictor was insignificant and so was the effect of need for cognition on the average originality of a solution.

**Predictors of Solution Effectiveness.** Individual differences in divergent thinking ability and need for cognition, and participants’ beliefs about creative courses, and curriculum and instructional design relevant coursework were hypothesized to predict the average effectiveness of a proposed solution. Thus, the initial regression model was a full model with five predictor variables, which included two divergent thinking indices (I, II), the composites of need for cognition, beliefs about creative courses, and the number of courses participants enrolled for relevant to curriculum and instructional design. Diagnostic statistics were obtained to determine outliers and the assumptions for multiple regression were examined for the full model after an outlier case was removed. The diagnostics procedure for detecting outliers and checking assumptions is summarized below and the full regression model is presented.

**Outliers.** Extreme points on the dependent and independent variables were detected to determine potential influential points in the model. An overview of the box-plot, the histogram, and the studentized deleted residuals index plot indicated that there is one extreme point on the predicted variable that was situated more than 3 standard deviations from the estimate. Diagnostic statistics were also obtained for the predictor variables including Centered Leverage values, Cook’s distances and the standardized DfFit statistic to detect potential influential points that could impact the regression model. A case was considered an influential outlier if it was three standard deviations from the mean of predicted scores and exceeded the cutoff criterion of greater than [1] for the standardized DfFit, which measures how much the predicted value changes when an observation is removed from the analysis. Thus, based on these criteria one case was removed from the sample. The regression model was fitted again and assumptions of linear
multiple regression were examined. The model included only the second divergent thinking index since it explained more variance than the first index.

**Normality.** To determine whether the assumption of normality is met the normal Q-Q plot of standardized residuals was examined. The residuals did not depart significantly from the 45-degree line, thus, the assumption of normality is satisfied for this regression model.

*Figure 4.2:* The normal probability plot for the solution effectiveness regression model.

**Linearity.** A 0-line was fit to the residual plot, in order to determine the extent to which the predictors exhibit a linear relationship with the dependent variable. The linearity assumption is met because the plot shows a random pattern as the points do not form a curve.

*Figure 4.3:* Linear 0-line fit on the residuals plot.

Information about the relation between the predictors and the dependent variable was derived from the matrix scatter plots of the predictors of solution effectiveness (see *Figure 4.4*). An overview of
the first row of the matrix with scatterplots of the predictors and the dependent variable, indicates that need for cognition has a weak linear relation with the average effectiveness of a solution but divergent thinking and beliefs about creative courses seem to be randomly related with the average effectiveness of a solution.

![Matrix scatter plots of the predictors of solution effectiveness.](image)

**Figure 4.4**: Matrix scatter plots of the predictors of solution effectiveness.

The Pearson correlations of the predictors with the dependent variable also show that the relations are weak. Need for cognition is significantly and positively related to solution effectiveness ($r_1 = .24$, $p = .01$), and relevant coursework and divergent thinking are positively but non-significantly related to the average solution effectiveness respectively ($r_2 = .15$, $p = .07$; $r_3 = .14$, $p = .07$). Beliefs and average solution effectiveness ($r_4 = -.02$, $p = .44$) are not significantly related.

**Table 4.10**

*Intercorrelations Between the Individual Difference Predictors and Average Solution Effectiveness*

<table>
<thead>
<tr>
<th></th>
<th>Divergent Thinking (II)</th>
<th>Relevant Coursework</th>
<th>Beliefs</th>
<th>Need for Cognition</th>
<th>Average Solution Effectiveness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Divergent Thinking (II)</td>
<td>-</td>
<td>.12</td>
<td>-.06</td>
<td>.14</td>
<td>.14</td>
</tr>
<tr>
<td>Relevant Coursework</td>
<td>-</td>
<td>-</td>
<td>.26**</td>
<td>.16</td>
<td>.15</td>
</tr>
<tr>
<td>Beliefs</td>
<td>-</td>
<td>-</td>
<td>.19</td>
<td>-</td>
<td>-.02</td>
</tr>
<tr>
<td>Need for Cognition</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>.24*</td>
<td></td>
</tr>
<tr>
<td>Average Solution Effectiveness</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
</tbody>
</table>

*p<.05, **p<.01.
**Homoscedasticity.** The distribution of the residuals was examined to determine whether the variance of the measurement error is constant across the values of the dependent variable. The residual plot of standardized residuals against the standardized predicted Ŷ values indicates a cloud of dots typical of a homoscedastic model exhibiting no specific shape or funnel to suggest that variance changes.

![Dependent Variable: Average Effectiveness](image)

Figure 4.5: Scatter plot of standardized residuals against standardized predicted values.

**Independence of errors.** The assumption of independence of residuals holds for the regression model as the Durbin-Watson coefficient’s value is \( d = 2.26 \) and its value falls between the range of \( 1.5 < d < 2.5 \) which indicates independence of observations (Kutner et al., 2005).

**Model.** A full model with the four predictors of solution effectiveness was fitted again after removing the one influential outlier. The multiple regression model was nonsignificant \([F(4,97) = 2.31, p = 0.06]\) and it only explained a small amount of the variance 8.4% in the average effectiveness of the solution as indicated by the coefficient of determination \((R^2 = 0.08)\). There was no evidence of multicollinearity for this regression model as the Tolerance collinearity statistics for the predictors were greater than the cut-off criterion of .20 and the Variance-inflation Factor (VIF) statistics for the predictors were smaller than the cut-off criterion of 4 (Kutner et al., 2005).
Table 4.11 presents the regression coefficients and the confidence intervals of the predictors of average solution effectiveness.

### Table 4.11

**Predictors of Average Solution Effectiveness**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Model 1</th>
<th>B</th>
<th>β</th>
<th>p</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>2.73**</td>
<td>2.82**</td>
<td>&lt;.001</td>
<td>[2.30, 3.35]</td>
<td></td>
</tr>
<tr>
<td>Need for Cognition</td>
<td>0.01*</td>
<td>0.01*</td>
<td>.24</td>
<td>.017</td>
<td>[0.002, 0.21]</td>
</tr>
<tr>
<td>Relevant Coursework</td>
<td>0.06</td>
<td>0.07</td>
<td>.13</td>
<td>.20</td>
<td>[-0.36, 0.17]</td>
</tr>
<tr>
<td>Beliefs</td>
<td>-0.01</td>
<td>-0.01</td>
<td>-.09</td>
<td>.36</td>
<td>[-0.02, 0.07]</td>
</tr>
<tr>
<td>Divergent Thinking (II)</td>
<td>0.02</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( R^2 )</td>
<td>0.09</td>
<td>0.08</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( F )</td>
<td>2.31</td>
<td>2.82*</td>
<td></td>
<td>.04</td>
<td></td>
</tr>
</tbody>
</table>

\*p<.05, **p<.01.

Need for cognition was the only significant predictor of solution effectiveness and for each unit of increase in need for cognition there is a 0.01 increase in the average effectiveness of the solution. Participants’ relevant coursework to curriculum and instructional design, their beliefs about creative solutions and divergent thinking did not predict the effectiveness of the solution they proposed. The variation among the participants with respect to their relevant coursework was limited because the majority of the participants were novices who enrolled either in one (64%) or two (19%) courses relevant to curriculum and instructional design. Thus, need for cognition but not the knowledge index of relevant coursework predicted the effectiveness of the solution. Since the majority of participants had relatively limited knowledge of curriculum and instructional design it was expected that their beliefs about creative courses would predict the average effectiveness of the solution. However, participants’ beliefs about creative courses did not predict the effectiveness of a proposed solution. This is possibly due to the restricted variability in beliefs about creative courses as it is indicated by the standard deviations of the
items on the beliefs scale. Divergent thinking was also a non-significant predictor of solution
effectiveness indicating that the ability to generate various ideas does not predict effective solutions.

In order to explore whether a reduced model could be more explanatory than the full model two reduced models were explored. The regression model reached significance ($F_{(3,98)}=2.82, p=0.04$) when the divergent thinking index (II) was removed from the full model. However, neither the significance of the regression coefficients of the remaining predictors nor the coefficient of determination ($R^2$) improved significantly. Table 4.11 presents the full regression model and the reduced model when divergent thinking (II) was removed from the model.

Finally, given that most of the participants were novices with limited knowledge of curriculum and instructional design, the effect of a more general domain knowledge index was examined. A dummy variable was added in Model 2 to represent participants who were education majors ($n_2=59$) in comparison to those who were non-education majors ($n_1=43$) in order to explore whether this domain knowledge proxy explains significant additional variance of the effectiveness of a proposed solution. The predictors of Model 2 and 3 with the added academic major predictor are displayed in Table 4.12.

**Table 4.12**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Model 2 $B$</th>
<th>$B$</th>
<th>$\beta$</th>
<th>$p$</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>2.82</td>
<td>2.83</td>
<td>&lt;.001</td>
<td></td>
<td>[2.31, 3.34]</td>
</tr>
<tr>
<td>Need for Cognition</td>
<td>0.01**</td>
<td>.01*</td>
<td>.22</td>
<td>.03</td>
<td>[0.001, 0.02]</td>
</tr>
<tr>
<td>Relevant Coursework</td>
<td>0.07</td>
<td>.06</td>
<td>.12</td>
<td>.25</td>
<td>[-0.04, 0.16]</td>
</tr>
<tr>
<td>Beliefs</td>
<td>-0.01</td>
<td>-.01</td>
<td>-.13</td>
<td>.19</td>
<td>[-0.02, 0.01]</td>
</tr>
<tr>
<td>Academic Major</td>
<td></td>
<td></td>
<td>.22*</td>
<td>.03</td>
<td>[0.03, 0.41]</td>
</tr>
<tr>
<td>$R^2$</td>
<td>0.08</td>
<td></td>
<td>.13</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$F$</td>
<td>2.82*</td>
<td></td>
<td>3.46*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\Delta R^2$</td>
<td></td>
<td></td>
<td>.05</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\Delta F$</td>
<td></td>
<td></td>
<td>5.06*</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*p<.05, **p<.01.
When academic major was added in the set of predictors in Model 3 there was a small but significant improvement in the variance explained by the regression model \( \Delta R^2 = .05, F_{(1,97)} = 5.06, p = .03 \).

A participant’s academic major predicts the effectiveness of a proposed solution. Specifically, for students who are enrolled in an education major the effectiveness of the solution they recorded was on average .22 points higher than the effectiveness of a solution proposed by a non-education major. Thus, it is likely that participants who are education majors probably relied on their prior knowledge beyond their knowledge of curriculum and instructional design to propose solutions that were more effective than those put forward by non-education majors.

**Creative Solution Self-Evaluation**

The fourth research question inquired about the comparative effect of an argumentation and an explanation reflective task on the self-evaluation of the proposed creative course with respect to its originality and effectiveness. Participants who responded to the argumentation task were asked to complete an argumentation diagram by filling in reasons for which their proposed course was a creative high school course with corresponding counterarguments that the school board members could raise, and then weigh each of the reason/counterargument pair. Thus, participants in the Argumentation condition had to reflect critically about the strengths and limitations of the creative course they proposed as a solution to the college dropout problem, in order to develop reasons supporting their creative course, and counterarguments that the board members could raise. In comparison, the participants who responded to the explanation prompt provided an explanation of their proposed creative high school course to the school board members. Participants in the Explanation condition were also expected to engage to some extend in reflective thinking by elaborating on their course and providing a justification but without considering any potential limitations of the course. Thus, it was hypothesized that for participants in the Argumentation condition the average solution effectiveness score would be strongly and positively predictive of the self-evaluation of the solution with respect to its effectiveness. Moreover, participants in the Argumentation condition were expected to rate their creative solution lower especially with respect to its effectiveness.
Self-Evaluation of Originality. Participants evaluated the creative course by providing estimates of the degree to which the high school course they proposed was original and effective by rating their course on 7 characteristics of originality and effectiveness respectively. A presentation of the means and standard deviations of the originality ratings across conditions and by condition are displayed in Table 4.13. In addition, mean differences between conditions in the ratings of the originality descriptors can be found in Table 4.13. Across conditions students rated moderately the overall originality of their proposed creative course and they considered their course to be primarily innovative \([M=3.22 (1.07)]\), original, \([M=3.10 (1.25)]\), unique \([M=2.99 (1.36)]\), and imaginative \([M=2.98 (1.28)]\).

In order to examine between group differences in the ratings of originality, multiple independent t-tests were conducted to investigate differences in the ratings of the originality descriptors. No statistically significant mean difference was found in the ratings of the originality characteristics among the two comparison groups. Moreover, the composite of the originality self-evaluations did not differ significantly between the two comparison groups suggesting that participants across conditions rated overall similarly their proposed course in terms of its originality.

Table 4.13
Mean, Standard Deviations and Mean Differences for the Self-Evaluations of the Originality of the Creative Course.

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Overall</th>
<th>Explanation Condition</th>
<th>Argumentation Condition</th>
<th>Mean Difference</th>
<th>d (SE)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(M (SD))</td>
<td>(M (SD))</td>
<td>(M (SD))</td>
<td>(M (SD))</td>
<td></td>
</tr>
<tr>
<td>Unique</td>
<td>2.99 (1.36)</td>
<td>3.13 (1.35)</td>
<td>2.83 (1.36)</td>
<td>.30 (.27)</td>
<td></td>
</tr>
<tr>
<td>Imaginative</td>
<td>2.98 (1.28)</td>
<td>3.05 (1.30)</td>
<td>2.90 (1.27)</td>
<td>.15 (.25)</td>
<td></td>
</tr>
<tr>
<td>Unusual</td>
<td>2.13 (1.37)</td>
<td>2.10 (1.38)</td>
<td>2.17 (1.37)</td>
<td>-.06 (.27)</td>
<td></td>
</tr>
<tr>
<td>Original</td>
<td>3.10 (1.25)</td>
<td>3.11 (1.27)</td>
<td>3.10 (1.25)</td>
<td>.01 (.25)</td>
<td></td>
</tr>
<tr>
<td>Novel</td>
<td>2.79 (1.29)</td>
<td>2.83 (1.31)</td>
<td>2.75 (1.29)</td>
<td>.07 (.26)</td>
<td></td>
</tr>
<tr>
<td>Innovative</td>
<td>3.22 (1.07)</td>
<td>3.35 (1.06)</td>
<td>3.08 (1.08)</td>
<td>.27 (.21)</td>
<td></td>
</tr>
<tr>
<td>Risky</td>
<td>1.76 (1.34)</td>
<td>1.59 (1.36)</td>
<td>1.94 (1.36)</td>
<td>-.35 (.26)</td>
<td></td>
</tr>
<tr>
<td>Originality SE Composite</td>
<td>18.96 (6.73)</td>
<td>19.16 (6.83)</td>
<td>18.76 (6.69)</td>
<td>.40 (1.33)</td>
<td></td>
</tr>
</tbody>
</table>
Self-Evaluation of Effectiveness. Participants evaluated their creative course by providing estimates of the degree to which the high school course they proposed was original as well as effective. Participants’ evaluations of their course in terms of effectiveness across experimental conditions and by comparison condition (i.e., Explanation, Argumentation) are presented in Table 4.14. Overall, students rated moderately high their creative course on the effectiveness characteristics. Specifically, participants appreciated highly their creative course as being goal-directed \([M=4.21(0.88)]\) and affordable \([M=3.96(1.03)]\), but also as being effective \([M=3.93(0.94)]\) and successful \([M=3.82(0.92)]\).

The descriptive statistics indicate that students in the Explanation Condition rated higher all effectiveness aspects of their course. It is possible that the students who completed the argumentation diagram and had to anticipate counterarguments relevant to their creative course were more conservative in their estimates since they identified some potential limitations of the course.

Table 4.14

Mean, Standard Deviations, and Mean Differences for the Self-Evaluations of the Effectiveness of the Creative Course

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Overall M (SD)</th>
<th>Explanation Condition M (SD)</th>
<th>Argumentation Condition M (SD)</th>
<th>Mean Difference d (SE)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Effective</td>
<td>3.93 (.94)</td>
<td>4.18 (.80)</td>
<td>3.67 (1.02)</td>
<td>.50 (.18)**</td>
</tr>
<tr>
<td>Successful</td>
<td>3.82 (.92)</td>
<td>4.03 (.77)</td>
<td>3.60 (1.01)</td>
<td>.42 (.18)</td>
</tr>
<tr>
<td>Affordable</td>
<td>3.96 (1.03)</td>
<td>4.15 (.95)</td>
<td>3.75 (1.08)</td>
<td>.39 (.20)</td>
</tr>
<tr>
<td>Organized</td>
<td>3.73 (.98)</td>
<td>3.96 (.92)</td>
<td>3.50 (.99)</td>
<td>.45 (.19)</td>
</tr>
<tr>
<td>Goal-directed</td>
<td>4.21 (.88)</td>
<td>4.39 (.81)</td>
<td>4.01 (.91)</td>
<td>.37 (.17)</td>
</tr>
<tr>
<td>Implementable</td>
<td>3.59 (1.18)</td>
<td>3.84 (1.12)</td>
<td>3.32 (1.20)</td>
<td>.52 (.23)</td>
</tr>
<tr>
<td>Feasible</td>
<td>3.45 (1.1)</td>
<td>3.63 (1.06)</td>
<td>3.26 (1.19)</td>
<td>.36 (.22)</td>
</tr>
<tr>
<td>Effectiveness SE</td>
<td>26.69 (5.38)</td>
<td>28.16 (4.59)</td>
<td>25.12 (5.75)</td>
<td>3.04 (1.02)*</td>
</tr>
</tbody>
</table>

*p<.05, ** p <.007

Independent t-tests were conducted to determine whether there were significant differences in how participants in the two conditions evaluated the characteristics of effectiveness. A Bonferroni-adjusted significance level of \(\alpha=.007 (\alpha=.05/7)\) for multiple t-tests was employed. One statistically
significant difference was detected as students in the Argumentation condition rated the course descriptor effective lower than students in the Explanation condition \([t(101)=2.80, \ p=.006, \ d=.05, \ 95\% \text{CI} (.15, .87)]\). All the rest of the differences in the ratings of the effectiveness descriptors failed to reach significance with the Bonferroni multiple-t tests. In addition, there was significant difference in the estimated composite of the effectiveness self-evaluation between the two comparison groups \([t(101)=2.97, \ p=.004, \ d=3.04, \ 95\% \text{CI} (1.01, 5.07)]\) indicating that overall participants in the Argumentation condition rate lower the effectiveness of their creative course.

The overview of the descriptive statistics for the originality and effectiveness self-evaluations indicates that the ratings of the creative course with respect to its originality were higher than the ratings assigned to the effectiveness descriptors. Moreover, the students in the Argumentation condition evaluated their high school course more conservatively with respect to its creativity and especially with regards to the effectiveness criteria.

**The Effect of Argumentation on Solution Self-Evaluation.** Engagement in different reflective tasks after proposing a solution to the problem was expected to have a differential effect on the self-evaluation of a potentially creative solution. Specifically, for students who responded to the argumentation task, the assigned average originality and effectiveness scores were expected to be strongly and positively predictive of their self-evaluations of the originality and effectiveness of the solution.

In order to examine the effects of the reflective tasks on the solution self-evaluations, a multivariate multiple regression was conducted by applying the General Linear Model approach (GLM). The multivariate model was the statistical analysis of choice instead of two separate multiple regression models because the two dependent variables namely the composites of the effectiveness self-evaluations and originality self-evaluations were significantly and positively correlated \((r_{12}=.38, \ p<.001, \ n=100)\). The bivariate correlations between the variables in the multivariate model are depicted in Table 4. 15. Participants’ beliefs are significantly but moderately correlated with the originality \((r=.37, \ p<.001)\) and effectiveness \((r=.38, \ p<.001)\) self-evaluations.
Table 4.15

*Intercorrelations Between the Continuous Variables and the Self-Evaluation Outcome Variables (n=100)*

<table>
<thead>
<tr>
<th>Relevant Coursework</th>
<th>Beliefs</th>
<th>Average Solution</th>
<th>Originality</th>
<th>Effectiveness</th>
<th>Originality SE</th>
<th>Effectiveness SE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Relevant Coursework</td>
<td>-</td>
<td>.26**</td>
<td>-.16</td>
<td>.13</td>
<td>.17</td>
<td>.17</td>
</tr>
<tr>
<td>Beliefs</td>
<td>-</td>
<td>.02</td>
<td>-.002</td>
<td>.37**</td>
<td>.38**</td>
<td></td>
</tr>
<tr>
<td>Average Solution</td>
<td>-</td>
<td>.12</td>
<td>-.07</td>
<td>.01</td>
<td>-.02</td>
<td></td>
</tr>
<tr>
<td>Originality</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Effectiveness</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Originality SE</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>.38**</td>
</tr>
<tr>
<td>Effectiveness SE</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**p<.01

Four predictors were entered in the full factorial model as covariates and the experimental condition with two levels (1=Explanation, 2=Argumentation) was entered as the fixed factor in the GLM. The four covariates included the composite score of beliefs about creative courses, the number of courses relevant to curriculum and instructional design that students enrolled for, and the average assigned originality and effectiveness score for the proposed solution. The diagnostics procedure for detecting outliers and checking assumptions is summarized below and the multivariate regression model is presented.

**Assumptions.** Three basic assumptions of Multiple Multivariate Regression were examined: (a) multivariate normality of the residuals, (b) homogeneity of the variances of the residuals, and (c) common covariance structure across observations (Burdenski, 2000).

**Univariate and Bivariate Normality.** In order to examine the assumption of multivariate normality, I first explored whether the univariate and bivariate normality assumptions were met. Univariate normality was investigated by examining the Normal Q-Q plots of residuals for the overall sample, by employing the Shapiro-Wilk normality test that is appropriate for small and medium samples up to n = 2000 (Garson, 2011), and by examining the skewness and kurtosis indices for each response variable.
The residuals in the Normal Q-Q plot of the residuals for the originality self-evaluations did not significantly departed from the reference line suggesting normally distributed residuals. In addition, the Shapiro-Wilk test of normality was conducted to further examine whether the univariate normality assumption was met.

Figure 4.6. The normal Q-Q plots of residuals for the originality self-evaluations.

The normality test failed to reach significance indicating that the observations of originality self-evaluations approximate normal across groups \( W_{(103)} = .99, p = .95 \). Finally, the skewness and kurtosis z-scores for the originality self-evaluations were within the acceptable range of values \( (z_s = -0.33; z_k = 0.06) \).

Figures 4.7. The normal residual Q-Q plots of the effectiveness self-evaluations.

Respectively, the Normal Q-Q plots of the residuals for the self-evaluations of effectiveness show that the majority of the residuals do not depart significantly from the reference line besides three possible outliers. However, the Shapiro-Wilk \( W_{(103)} = .95, p < .001 \) test was rejected, indicating that the distribution
of self-evaluations was not approximately normal. To further examine the distribution of the effectiveness self-valuations the $z$-scores for the skewness and kurtosis statistic were calculated ($z_s=-3.65$; $z_k=2.55$), and they suggested that the distribution was somewhat skewed. An overview of the histogram and box plot for the effectiveness self-evaluations indicated that there are three outliers in the distribution that could potentially impact the normality of this distribution and they were further examined to determine whether they represent influential cases.

Univariate normality is a precondition for multivariate normality but for a complete understanding of multivariate normality I proceeded to examine the bivariate normality of the two response variables by examining their scatter plot (Burdenski, 2000). Given that the response variables of originality and effectiveness self-evaluations are significantly and moderately correlated, their scatter plot should be approximately elliptical as it is shown in Figure 4.8. A few points seem to represent potential multivariate outliers and these were examined in a follow-up test.

Given that in a data set of two or more dependent variables all of the variables must be univariate normal and all possible pairs of the variables must also be normal, the Mardia’s (1974) tests of multivariate skewness and kurtosis were performed to examine bivariate normality.

![Figure 4.8. Scatterplot of the originality and effectiveness self-evaluations.](image-url)
The multivariate kurtosis assumption was met ($b=8.92; p=.25$) but the bivariate distribution seems to be somewhat skewed ($b=.86; p=.003$). However, given that Mardia (1971) demonstrated that MANOVA is robust to modest violation of normality if the violation is caused by skewness instead of outliers the next step was to determine whether there were any significant multivariate outliers and influential cases.

**Outliers.** The statistic Mahalanobis distance ($D^2$) was used to detect cases that significantly deviate from the mean adjusting for the correlation of the two response variables. The SPSS Macro developed by De Carlo (1997) to explore multivariate skewness and kurtosis generates critical values for testing multivariate outliers for the five observations with the largest Mahalanobis distances ($D^2$) and a plot of ordered squared distances. None of the five cases with the largest ($D^2$) were significant outliers as they did not exceed the critical $F$ value but one case had an extreme Mahalanobis distance ($D^2$) and was removed from the sample. In addition, potential extreme values in the covariates were also examined because multiple regressions conducted in GLM with independent variables as covariates are sensitive to the outliers in the covariates. Two cases had high leverage values on both dependent variables. These two cases were removed from the dataset as they were influential points that changed significantly two parameters estimates (i.e., average assigned originality and effectiveness scores). When the three excluded cases were removed the assumption of multivariate normality was met based on Mardia’s multivariate normality test ($\chi^2_{(4)} = 4.88, p=.30$) and the univariate skewness improved to approach normality ($b=.45; p=.11$). The multivariate regression analysis reported was performed without the three influential cases in the covariates ($n=100$), 53 participants in the Explanation condition and 47 in the Argumentation condition.

**Homogeneity of Variances.** The second assumption of the homogeneity of the residual variances was also met as the Levene test indicated that for both response variables, the null hypothesis that the error variances for the Explanation and Argumentation condition are equal was retained for the sum of the originality self-evaluations [$F_{(1,98)}=0.06, p=.82$] and the effectiveness self-evaluations [$F_{(1,98)}=1.02, p=.75$]. As far as the third assumption regarding the equality of covariances across the two
groups, the $F$ statistic for the Box test of the equality of the covariance matrices was non-significant ($F=.44, p=.73$). Thus, the null hypothesis that the covariance matrices are equal across the Explanation and Argumentation group was retained.

**Independence.** Finally, to examine the distribution of residuals the observed, predicted and standardized residual plots were examined for the two outcome variables namely the originality and effectiveness self-evaluation scores. An overview of the plots indicates no pattern between predicted values and standardized residuals, and a linear trend for the observed by predicted values, which suggests an adequately fitting model. However, there is a linear trend between the observed values and the standardized residuals, which indicates that as the observed value of originality and effectiveness self-evaluations increase the model error increases, which suggests a potential dependency of errors.

![Matrix scatter plots](image)

**Figures 4.9 & 4.10.** Matrix scatter plots of the predictors of originality and effectiveness self-evaluations.

Thus, a Durbin-Watson coefficient was obtained for the residuals of the self-evaluations of originality and effectiveness to test for error dependency (i.e., autocorrelation). The value of the Durbin-Watson statistic ranges between 0 and 4. When the Durbin-Watson coefficient falls between 1.5 and 2.5 it indicates independence of observations. For both regression equations, the Durbin-Watson statistic $d$ fell within this range ($d_1=1.71; d_2=2.05$) and consequently the assumption that the residuals are not serially correlated is retained. Thus, the conclusion was that despite the linear trend in the plot of observed and standardized residuals, the residuals are not significantly correlated.
**Predictors of Solution Self-Evaluations.** Participants self-evaluated their creative course by providing estimates about a set of characteristics descriptive of the originality and effectiveness of the course that participants forwarded as a potential creative solution to the problem. Participants self-evaluated their course after they had reflected on the course either by providing an explanation to the school board or by recording reasons and potential counterarguments about the course. In order to determine the predictors of the self-evaluations and determine the relevant effect of the two reflective tasks on the self-evaluations, a multiple multivariate regression model (MMR) was performed using the GLM approach. Before conducting the MMR analysis, pre-existing differences across the two experimental conditions in the four variables entered as covariates were examined by conducting multiple comparison t-tests. No statistically significant differences between the experimental conditions were detected in the four covariates namely relative course work, average originality and effectiveness score for the creative course, and beliefs about creative courses.

**Model.** The multivariate multiple regression model was significant \( F(2,94)=11.81, p<.001, \eta^2 =.20 \) as it was indicated by the Hotelling’s Trace, which is the most commonly used statistic when there are two groups formed by the independent factor (Garson, 2012). The multivariate model explained 20% of the combined variance in the self-evaluations of originality and effectiveness. The multivariate test examines whether each effect is significant for at least one of the dependent variables. Only beliefs about creative courses and the Experimental condition had a significant effect and they explained 20% of the variance \( F(2,93)=11.79, p<.001, \eta^2 =.20 \). The type of reflective task that participants completed (i.e., Experimental condition) was also a significant predictor of self-evaluations \( F(2,93)=5.82, p=.004, \eta^2 =.11 \). The average originality of the solution \( F(2,93)=0.24, p=.32, \eta^2 =.02 \) and the average effectiveness of the proposed solution \( F(2,93)=.001, p=.94, \eta^2 =.001 \) did not predict significantly any of the outcome self-evaluations. Finally, the number of the courses relevant to curriculum and instruction that participants enrolled for \( F(2,94)=.006, p=.75, \eta^2 =.01 \) did not significantly explain any variance of the course originality and effectiveness self-evaluation scores.
Given that the fourth research question inquired about the comparative effect of the Explanation and the Argumentation condition on the self-evaluations of originality and effectiveness, the separate effects on the originality and effectiveness self-evaluations were examined. The test of between-subject effects tests the null hypothesis that there is no difference in the means of each dependent variable for the two comparison groups formed by the type of reflective task. Beliefs about creative courses and the type of reflective task (i.e., Explanation, Argumentation) were significant predictors of the differences in the self-evaluations of originality and effectiveness.

**Effect on Originality Self-Evaluations.** The specified model explained 15% of the variance in the evaluations of the originality of the proposed creative course $[F(5,94)=3.19, p=.01, \eta^2=.15]$. Beliefs about creative courses significantly and positively predicted originality self-evaluations $[F(1,94)=12.69, p<.001, MSE=518.05, \eta^2=.12]$, which means that the more aligned were participants’ beliefs about the characteristics pertaining to the originality of a creative course the higher they rated the originality of their proposed solution. Specifically, for each unit of increase in beliefs there was a .33 unit increase in self-evaluations of originality for the proposed course $[b=.33, t=3.56, p<.001, 95\%CI(.14, .51)]$.

The average originality score assigned to the learning activities of a proposed solution did not explain significant variance in the participants’ self-evaluations with respect to originality $[F(1,95)=.44, MSE=17.96, p=.51, \eta^2<.01]$. Thus, variance in participants’ originality self-evaluations of their proposed creative course was not explained by the originality score assigned by the rater to the set of learning activities that a participant listed for their creative high school course.

The experimental condition did not have a statistically significant effect on the self-evaluations of originality $[F(1,94)=.12, MSE=4.94, p=.73, \eta^2=.001]$. Nevertheless, a descriptive trend in the contrast estimate indicated that comparatively participants who completed an argumentation diagram and who were equal on other predictor variables in the model with participants who provided an explanation of their creative course to the board members, rated on average lower the originality of their solution in comparison to those participants who developed an explanation $[M_d=.45, p=.73, 95\%CI(-2.1, 3.0)]$. 
**Effect on Effectiveness Self-Evaluations.** The model explained more variability (26%) in the estimates of the effectiveness self-evaluations \(F(5, 94) = 6.44, MSE = 119.28, p < .001, \eta^2 = .26\) in comparison to the estimates of the originality self-evaluations. Beliefs about the nature of creative courses \(F(1, 94) = 17.59, MSE = 325.95, p < .001, \eta^2 = .16\) and the type of reflective task \(F(1, 94) = 11.39, MSE = 210.95, p = .001, \eta^2 = .11\) explained significant variability in the self-evaluations of the effectiveness of a proposed solution. Beliefs about creative courses was a significant positive predictor of the effectiveness self-evaluations \(b = .26, p < .001, 95\% CI (.14, .38)\) and for each unit of increase in the beliefs about creative courses there was a .26 increase in the self-evaluations of the effectiveness of a solution. Thus, the more aligned the participants’ beliefs were with current perceptions of creative outcomes the higher they evaluated both the originality and the effectiveness of the solution.

The average effectiveness score assigned by the rater to the learning activities of a proposed course was a negative but not significant predictor \(F(1, 94) = .08, MSE = 1.52, p = .78, \eta^2 = .001\) of effectiveness self-evaluation scores. Thus, participants’ self-evaluations of the effectiveness of their proposed creative course were not predicted by the average effectiveness score assigned to the generated learning activities of the course by the rater.

With respect to the effects of the type of reflective task on the self-evaluations of the effectiveness of the creative course the type of reflective task that participants responded to, accounted for significant difference in the self-evaluations of effectiveness given by the participants \(F(1, 94) = 11.38, MSE = 210.95, p = .001, \eta^2 = .11\). In fact, for two individuals equal on other predictor variables in the model, the participants in the Argumentation condition assigned lower effectiveness self-evaluations for their creative course on average by 2.93 points \(M_d = 2.93, p = .001, 95\% (1.20, 4.65)\) in comparison to those in the Explanation condition. Thus, participants who completed an argumentation diagram and generated arguments and counterarguments to the overarching question asking whether their course represents a creative high school course were more conservative but accurate in their self-evaluations of creative courses by three points on the self-evaluation of effectiveness scale. This finding suggests that
argumentation diagrams may represent a graphic organizer that provides support to problem solvers to be more reflective and critical about the solutions they generate.
CHAPTER 5

Conclusions and Implications

Students in K-16 settings are frequently challenged to achieve learning outcomes and exhibit high levels of cognitive skills based on the Bloom’s taxonomy of learning objectives such as to manifest their creativity by combining or reorganizing elements to form a coherent or functional whole or a new structure, form or idea (Anderson & Krathwohl, 2001). The present study drew on two paradigms of research namely ill-structured problem solving and creative problem solving to comprehensively investigate the variables that contribute to creative problem solving performance. In addition, the study attempted to address a gap in the literature concerning the effectiveness of a type of argumentation structure support in facilitating reflective self-evaluation of a proposed solution. Specifically, the study examined the comparative effects of an Argumentation Vee Diagram and an Explanation prompt on the self-evaluation of a high school course that undergraduate students proposed as a potential creative solution. In this chapter, I summarize and discuss the main findings of the present study with respect to the development of creative solutions and their self-evaluation, by drawing on the literatures of creative and ill-structured problem solving. In addition, I discuss the main limitations of the study and propose implications for educational research and practice.

The theoretical and empirical literatures of creative and ill-structured problem solving have identified general intellectual abilities, knowledge variables, self-regulatory, and motivational/affective variables that contribute in creative problem solving performance. The results of the study aligned with research findings about the predictors of creative problem solving. For the purposes of the present study the creative outcome that the participants developed was a college preparatory course designed to address the high dropout rate among a high school’s graduates. An average effectiveness and originality score was assigned to the proposed course based on the originality and effectiveness of the learning activities that participants listed and described as components of their course. Based on the findings of the study, I will discuss the variables that predict creative problem solving performance and the self-evaluation of a proposed solution and point to potential directions for future research.
Predictors of Creative Performance and Solution Self-Evaluation

**Divergent Thinking.** As it was hypothesized individuals with high divergent thinking scores were more likely to propose a more original solution. Divergent thinking has been consistently reported as a predictor of creative problem solving with positive effects on the degree of originality of a solution (Diakidoy & Constantinou, 2001; Hunter et al., 2008; Reiter-Palmon et al., 1997). Despite the fact that the contribution of divergent thinking in creative performance has been challenged by researchers (Weisberg, 2006), the ability to generate various, distinct responses to a traditional divergent thinking task such as the Consequences A’ Form (Christensen, Merrifield, & Guilford, 1953) administered in this study, was found to be predictive of the originality of the solution proposed to a course design task.

**Knowledge and Beliefs.** Participants’ relevant coursework in curriculum and instructional design was considered to be a prior knowledge proxy and it was found to be a negative predictor of average solution originality. Individuals who enrolled in more courses were less likely to generate a more original solution. Moreover, the knowledge proxy relevant coursework in curriculum and instructional design did not significantly predict the effectiveness of a solution. Domain knowledge is identified as a powerful predictor in the empirical literature of ill-structured problem solving and creativity researchers have made the argument that domain knowledge of the facts, concepts, principles, and cognitive processes are critical for one to be able to associate, transform, extend or reorganize knowledge in order to develop creative solutions (Amabile, 1983; Csikszentmihalyi, 1999; Weisberg, 2006).

It is possible that the prior knowledge proxy used in this study was not adequately valid as it was dependent on participants’ recall ability and their perception of which courses they enrolled are relevant to curriculum and instructional design. As a case in point, when the academic major of a participant (i.e., education vs. non-education major) was included in the model as a prior knowledge proxy, it positively predicted the effectiveness of a solution. In order for creativity researchers to move beyond the generalist framework of creative problem solving, measures of domain knowledge with sound psychometric properties need to be administered in order to gauge the contribution of domain knowledge in the development of creative solutions.
Participants’ beliefs about creative courses aligned moderately with the characteristics of creative outcomes as they have been conceptualized in the theoretical and empirical literatures of creativity. The undergraduate students who participated in the study perceived a creative course as one that is primarily feasible, effective, innovative and successful. This finding contradicts the results of previous research on beliefs about creativity which revealed that in most instances a creative outcome was distinguished for its novelty, and originality was considered to be the main descriptor of creative outcomes (Andiliou & Murphy, 2010). Given that in the present study participants’ beliefs about creative outcomes were explored with respect to creative courses, the nature of the outcome might have resulted in effectiveness characteristics to be more highly rated. Despite my hypothesis, beliefs about creative outcomes (i.e., creative courses) did not predict either the average originality or effectiveness of the proposed creative high school course. However, the role of beliefs about creative outcomes may be more prominent in problem solving in other domains and educational researchers need to further investigate their role before drawing conclusions about their contribution in problem solving performance. Moreover, the impact of other affective variables such as creative self-efficacy needs to be explored as research findings indicated that the development of creative self-efficacy is accompanied by increases in creative performance in a work context (Tierney & Farmer, 2011).

Beliefs about creative outcomes positively and significantly predicted participants’ self-evaluations of their proposed creative high school course. Participants whose beliefs aligned better with the conceptualizations of creative outcomes as framed in the theoretical and empirical literature of creativity and creative problem solving, rated higher their creative course with respect to its originality and effectiveness. Thus, the findings of this study confirm the hypothesis that problem solvers’ beliefs about the characteristics (i.e., nature) of creative outcomes positively predict judgments of how creative a proposed solution is, which confirms that ontological beliefs about the nature of creative solutions play an important role in the evaluation process. Educational researchers have shown interest in examining the role of epistemological beliefs on problem solving performance (Lodewyk, 2007; Muis, 2008; Oh & Jonassen, 2007) but further research needs to be conducted to investigate the role of beliefs in establishing
criteria for judging solutions in various knowledge domains, especially in cases in which a creative solution is required and learners have to draw on their beliefs about creative outcomes to evaluate a solution.

**Need for Cognition.** A learner’s tendency to engage in and enjoy effortful and challenging endeavors such as seeking an original and effective solution to an ill-structured problem predicted the effectiveness of the creative outcome. The participants’ reported Need for Cognition was moderate to low, which is worrisome since the cognitive disposition to enjoy effortful and challenging endeavors would seem a prerequisite for lifelong learning and continued professional development that is essential for any future educator. Educational researchers can further explore pre-service teachers’ Need for Cognition as it represents an important individual difference variable that can potentially impact their commitment to professional development and teaching effectiveness. Need for cognition positively predicted the effectiveness of the creative high school course that participants proposed as a solution to the college dropout rate among the high school’s graduates. Thus, the present study provides evidence that need for cognition is a motivational variable that promotes creative problem solving. The finding adds to existing evidence that indicate that individuals with higher need for cognition performed more effectively in solving complex problems (Butler et al. 2003; Hunter et al., 2008; Nair, & Ramnarayan, 2000; Osburn & Mumford, 2006). Need for cognition is possibly related with more perseverance during complex problem solving as Nair and Ramnarayan (2000) found that individuals higher in need for cognition collected more relevant information, made decisions on more aspects of the problem and faced fewer crises during the process.

**The Effectiveness of the Argumentation Vee Diagram.** The study aimed to examine ways to support reflective self-evaluations of the proposed creative solutions. Thus, I examined the comparative effect of two types of reflective tasks: an argumentation diagram and an explanation prompt, in predicting the self-evaluation of a creative solution. The type of reflective task that participants completed before evaluating their proposed course predicted the self-evaluation of the effectiveness of the creative high school course. Specifically, participants who completed an Argumentation Vee Diagram evaluated the
effectiveness of their creative high school course on average 3 points lower, on a scale ranging from 0 to 35, in comparison to participants who completed an explanation prompt and who were equal on other predictor variables, including beliefs about creative outcomes, relevant coursework in curriculum and instructional design, and the average assigned originality and effectiveness score.

Participants who argued about whether their proposed course is a creative high school course, evaluated their course lower in terms of effectiveness possibly because the argumentation diagram supported more deep, reflective and critical thinking about the proposed solution (Nussbaum, 2008). In contrast, individuals who responded to the explanation prompt worked under the assumption that their proposed course is in fact a creative high school course and they needed to provide an explanation to the school board members through presenting and elaborating aspects of their proposed high school course. One can reasonably argue that the argumentation diagram provided a structure support for students to move beyond elaboration to reflect and critically analyze their solution by exploring and integrating reasons for which the course is a creative one and weigh each reason with counterarguments that the school board might raise (Jonassen & Kim, 2010, Nussbaum & Sinatra, 2008).

An overview of participants’ arguments provides evidence for the interpretation that the argumentation diagram supports reflective thinking. In their reasons, participants argued for the importance of a course that will prepare students for the transition to the college life and environment by using a creative approach that promotes learning and student engagement. Also, participants argued that a college preparatory course would develop important social skills, strengthen self-esteem and self-regulation and improve students test taking, note taking, time management and study skills. In addition, participants who completed the argumentation diagram generated potential reasons that the school board members or parents could raise about their creative high school course. Participants projected that there would be concerns about how to develop the curriculum for the course and how to assess student learning. In addition, according to the participants in the Argumentation condition, the school board members may argue that the subject courses already prepare students for college and that such a course fits neither the
curriculum nor the budget of the school. In contrast, participants who responded to the explanation prompt focused on presenting in a more elaborative way their creative course.

The explanation prompt encouraged reflective thinking to some degree as participants described their course but also explained the importance of a creative preparatory high school course. An overview of the explanations indicated three emergent themes in participants’ explanations of their course. Students discussed the value of the course, provided an overview of the content of the course, and specified some of the learning activities that they plan to implement. Further research in which a think aloud methodology is applied can provide evidence about the differences in cognitive processing while learners respond to an explanation prompt or an argumentation diagram and how explanation and argumentation impact differently the judgments learners draw about a solution.

The findings of the study indicate that the nature and the goal of the problem solving task also play a role on how participants evaluated a potentially creative solution. The task required participants to take a creative approach in designing and teaching a high school course in order to reduce the college dropout rate among the high school’s graduates. The goal of the problem solving task seems to have informed the evaluations of the high school course since the participants rated their creative course higher with respect to the effectiveness than originality characteristics of a creative outcome. Thus, given the context of the task, learners valued more criteria related to the effectiveness of the solution. Specifically, the goal-directedness, affordability, and effectiveness of the creative high school course were rated high. The characteristic innovative was the only originality characteristic that the participants rated their creative course relatively high. Thus, the findings suggest an interplay between the nature of the problem solving task and specifically the goal(s) of an ill-structured problem and learners’ beliefs about creative outcomes (i.e., solutions, ideas, products), which is manifested in the evaluations of the characteristics of a proposed creative solution.

Limitations

Sample. Participants were recruited from an introductory Educational Psychology course and the most of them were freshman (30%) and sophomores (52%). Nearly two thirds of the students were
education majors (57%), several were non education majors (50%) and a few (3%) were enrolled under the Division of Undergraduate Studies. Thus, arguably the participants had relatively low curriculum and instructional design knowledge and it is reasonable to argue that they relied more on personal experiences and preferences to generate specific learning activities for their creative high school course. This can potentially explain why prior knowledge with respect to relevant coursework in curriculum and instructional design did not significantly predict the effectiveness of a solution but a participant’s academic major was a significant positive predictor. A sample comprised by more senior education majors would allow examining more efficiently the effects of prior knowledge on creative problem solving.

Procedure. To establish the validity of the coding scheme and the reliability of the coded responses to the problem solving task, the researcher and another educational psychology graduate student, worked independently to develop the coding scheme and then to code a subset of the responses to the problem solving task. The intercoder agreement for the number of ideas and the type of code assigned to each idea was moderate but acceptable. Given the nature of the problem solving task and the moderate intercoder agreement it would be advisable to implement more elaborative coding procedures by having the two coders code independently either a larger percentage of the response set or the entire set of responses or use more than two coders. However, due to time constraints in the completion of the study, the fact that the coder was involved on a voluntarily basis but also since the moderate intercoder reliability was acceptable based on the adopted criterion, only a subset of the responses were coded to estimate the intercoder reliability coefficients.

Measures. Limitations in the design of two of the measures and the reflective tasks administered in this study are discussed below:

Prior Knowledge Proxy. Participants’ prior knowledge was measured by using the self-reported number of courses relevant to curriculum and instructional design that participants had enrolled so far. This self-reported proxy of prior knowledge might not have been the most valid measure of general pedagogical knowledge, which could explain why the relevant coursework was a significant predictor in
only one model estimating the effects of knowledge on the average originality of a proposed solution. Although general pedagogical knowledge is considered an important aspect of teaching effectiveness, by the time that the present study was administered, no validated measure of pedagogical knowledge was available for use in educational research.

The results of the construction and validation of a measure of general pedagogical/psychological knowledge (PPK) were reported two months after the administration of this study in the Journal of Educational Psychology (Voss, Kunter, Baumer, 2011). The authors defined PPK as the knowledge needed to create and optimize teaching-learning situations across subjects, including declarative and procedural knowledge of classroom management, teaching methods, classroom assessment, knowledge of student heterogeneity that includes knowledge of students’ learning processes and individual characteristics (Voss, Kunter, Baumer, 2011, p. 2). This newly developed measure of general pedagogical/psychological knowledge is a 39-item measure comprised by multiple choice items, short answer questions, and video-based items. Various sources of validity evidence were reported by the authors including evidence based on internal structure that supported the nomological network, relations to discriminant constructs, and evidence based on relations with student ratings of high instructional quality for lessons taught by teacher candidates. This represents a promising attempt to construct and validate a usable measure of teacher’s domain knowledge but cautious use of this measure of PPK is advised before further validation.

**Creative Course Beliefs Questionnaire.** Students’ beliefs about the characteristics of a creative course were measured on a 28-item Likert scale. Twelve of the items described the qualities of a creative course and the remaining items were distracters relevant to two conceptual categories namely factors associated with academic success in college and beliefs about curriculum and curriculum design. In comparison to the other individual difference measures this was the lengthiest measure administered in this study. Given that participants responded to the demographics questionnaire, completed two divergent thinking tasks, and the need for cognition scale in addition to the beliefs questionnaire, they might have experienced some fatigue when they reached the point of constructing a response to the problem solving
task, which can also explain the brevity of the responses. Since this issue was also raised by one of the experts who completed the study for validity purposes, in future administrations of the questionnaire a shorter version of it could be implemented.

**Reflective Tasks.** The format of the two reflective tasks the Explanation and the Argumentation Vee Diagram differed. Participants in the Explanation condition provided the explanation of their proposed creative course in a short paragraph format. However, participants in the Argumentation condition recorded the arguments and counterarguments about their creative course in two columns of the Argumentation Vee Diagram and then indicated for each pair of argument-counterargument, which side is stronger. The fact that the reflective tasks differed with respect to their format structure might have influenced participants’ degree of engagement with the reflective task. A more comparable format might have been to require students in the Explanation condition to generate in two different columns of a table an outline of the explanation of their creative course to the school board (i.e., Column 1) and to the parents of the high school students (i.e., Column 2). Moreover, the Argumentation Vee Diagram was a novel type of graphic organizer and its novelty might have caused participants to be more interested and engaged when developing reasons and objections to fill in the diagram. Thus, it is possible that the difference in the format and the novelty of the Argumentation task might have contributed in promoting more cognitive engagement when participants reflected on their creative high school course they generated. A follow-up study in which the effect of the Argumentation Vee Diagram is compared with an alternative comparable argumentation task such as a pros/cons grid can provide stronger evidence about the effect of the argumentation diagram when the format of the two graphic organizers is similar.

**Implications and Directions for Future Research**

The purpose of the study was to explore creative problem solving performance and examine ways to support reflective self-evaluations of the proposed creative solutions. The study examined the effect of a number of individual difference variables on creative problem solving performance including the role of prior knowledge measured by the number of relevant coursework in curriculum and instructional design.
The participants in the study had low to moderate prior knowledge. Researchers who aim to examine the effects of domain knowledge in creative problem solving can extend the research to more expert populations to determine whether domain knowledge has a more pervasive role on creative problem solving and the self-evaluation of creative outcomes.

For the present study the participants in the experimental condition completed an Argumentation Vee Diagram by filling in the arguments and counterarguments to whether their suggested solution represented a creative high school course and then indicating for each argument-counterargument pair which side was stronger. Thus, the way in which the argumentation task was structured required participants to apply the weighing argument-counterargument integration strategy (Nussbaum & Schraw, 2007) based on which they consider both sides and then decide which has stronger arguments. A follow-up study that would implement a think aloud methodology would allow for a more authentic assessment of the argument-counterargument integration strategies (e.g., synthesis, refutation, and minimization) that learners choose to apply when they are not required to use a preselected integration strategy. Specifically, as Nussbaum (2008) argued, the use of synthesis is an alternative and less frequently used argumentation strategy in which the arguer finds a final standpoint between different sides. The use of synthesis is expected to be an effective strategy for tasks that require a creative solution since such tasks often require finding a solution in which benefits are realized while disadvantages are minimized (Nussbaum, 2008, p. 551). A think aloud approach would allow the examination of the integration strategies that are more effective for reflecting and integrating the arguments and counterarguments of a potentially creative solution.

Among the contributions of the present study is the development of the self-evaluation questionnaire that allows learners to assess the creativity of a solution they have generated with respect to a set of originality and effectiveness characteristics. Further validation of the questionnaire is required to determine whether the scale yields the same underlying structure when is used to self-evaluate outcomes (e.g., products, solutions, ideas) generated in other fields outside education.
Implications for Practice

Creativity, innovation, and problem solving have been identified among the essential skills that students need to possess for the 21st Century (Partnership for 21st Century Skills, 2011). The present study focused on the effects of an explanation and an argumentation task in promoting reflective thinking about a creative solution. Drawing on the findings of this study, an Argumentation Vee Diagram represents an effective organizer in which students can record reasons for proposing a solution, project potential objections to a solution, and weigh their arguments and counterarguments to critically evaluate their solution. Moreover, the findings of the study indicate that more attention needs to be directed towards affective dimensions of learning such as students’ beliefs about creative outcomes as they were found to inform students’ evaluations of a potentially creative solution to an ill-structured problem. Finally, the present study offers a scale that teachers and learners can use as an evaluation tool to rate the creativity of an outcome developed during classroom or assessment activities with respect to its originality and effectiveness.

When teachers design learning activities and authentic assessments to promote problem solving skills, a potential means to support reflection and critical self-evaluation is to embed argumentation components in the activities by including argumentation diagrams that are individually or collaboratively constructed and discourse based on argumentation. Such activities can also be used as opportunities to explore students’ conceptualizations of creative outcomes (i.e., ideas, solutions, products). Thinking as argument is implicated in the beliefs that people hold, the judgments they make, and the conclusions they come to; it arises every time a significant decision must be made (Jonassen & Kim, 2010, p. 439). The findings of this study encourage education practitioners to incorporate argumentation activities in the learning environment in order to facilitate reflective self-evaluations and critical thinking about ideas, beliefs, decisions and solutions that students put forward.
Appendix A

ORP-Approved Recruitment and Consent Form

IMPLI ED CONSENT FOR SOCIAL SCIENCE RESEARCH - The Pennsylvania State University

Title of Project: The effects of argumentation on creative problem solving.

Principal Investigator: Academic Advisor:
Andria Andiliou P. Karen Murphy
301 Rider Building 229 Cedar Building
University Park, 16802 University Park, 16802
aua167@psu.edu pkm15@psu.edu
814 863 2599 814 863 2278

1. Purpose of the Study: The primary purpose of this study is to investigate students’ problem solving relevant to educational issues.

2. Procedures: A survey link will be uploaded on EDPSY 14 Angel webpage (https://pennstate.qualtrics.com/SE/?SID=SV_bpjVxLqCSAOQbd). In order to access the online survey you need to enter your webmail address (e.g., aaa123@psu.edu). For this study you will complete a demographic cover page, two divergent thinking tasks, a beliefs measure and a need for cognition questionnaire. Then you will read a scenario about an educational issue, and respond and reflect to the issue.

3. Duration: If you agree to participate in the study, you will complete an online survey that lasts 50 minutes.

4. Statement of Confidentiality: Your participation in this research is confidential. The anonymize responses function of the online survey software will not link your responses to your webmail username. In the event of any publication or presentation resulting from the research, no personally identifiable information will be shared. The Pennsylvania State University’s Office for Research Protections and Institutional Review Board, and the Office for Human Research Protections in the Department of Health and Human Services may review records related to this project.

5. Potential Discomforts or Risks: The study presents no known risks for the participants. The webmail username you have provided will not be linked to your responses because the anonymize response function of the online survey software will delete your webmail username from the dataset.

6. Right to Ask Questions: Please contact Andria Andiliou (aua167@psu.edu) with questions, complaints, or concerns about this research. You can also email the researcher if you feel this study has harmed you. If you have any questions, concerns, problems about your rights as a research participant or would like to offer input, please contact The Pennsylvania State University’s Office for Research Protections (ORP) at (814) 865-1775. The ORP cannot answer questions about research procedures. Questions about research procedures can be answered by the researcher team.

7. Compensation: In return for your participation, you will receive 3 points of your final grade.

8. Alternative to Participation: If are not interested in participating in the study you can still earn the 3 points if you choose to submit a 2-3 page critique of a journal article. The critiques need to be completed within the time frame for the study and must be submitted to the researcher for review.

9. Voluntary Participation: Your decision to be in this research is voluntary. You can stop at any time. Refusing to participating or withdrawing from the study involve no penalty or loss of benefits you would be entitled to
otherwise. You do not have to answer any questions you do not want to answer but try to do your best in every question.

10. **Benefits:** Students who will participate in the study will receive different types of supports to solve an educational problem in order to determine scaffolds that facilitate creative problem solving.

You must be 18 years of age or older to consent to participate in this research study.

Completion of the online survey implies that you have read the information in this form and consent to participate in the research.

ORP OFFICE USE ONLY – DO NOT REMOVE OR MODIFY: This informed consent form (Doc.# 1001 ) was reviewed and approved by The Pennsylvania State University’s Office for Research Protections (IRB#36477) on 09-06-2011. It will expire on 03-08-2011. (JDM)
Appendix B

Demographic Page

Please, fill in the blanks and respond to the questions below.

- **Gender**: 
- **Ethnicity**: 
- **Major Area of Study**: 
- **Minor Area of Study (enter none if you don't have one)**: 

Select your college classification.

- [ ] Freshman  
- [ ] Sophomore  
- [ ] Junior  
- [ ] Senior  
- [ ] Certification  
- [ ] Masters  
- [ ] PhD  
- [ ] Other

Indicate your grade point average (GPA).

List the titles of any courses you have taken relevant to curriculum and instructional design.

Briefly describe any course(s) you took to prepare you for the transition to college.

List any teaching experiences that you have had so far.
Appendix C

Pre-Problem Solving Measures

Divergent Thinking

**TIME: 120**
What would happen if a new invention made it unnecessary for people to eat?
You have 2 minutes (120 secs) to list as many different consequences or possible results if this imaginary situation was true.

**TIME: 120**
What would happen if a new invention made it unnecessary for people to sleep?
You have 2 minutes (120 secs) to list as many different consequences or possible results if this imaginary situation was true.
Creative Course Beliefs Questionnaire

Drag the slider to indicate **how much you agree** with each statement.

<table>
<thead>
<tr>
<th>Not Very</th>
<th>Very Much</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>

- Success in college is related with higher 1st year GPA.
- Creative high school courses are innovative.
- When designing a curriculum, the development of cognitive skills is the basic goal.
- Success in college is related with higher SAT math score.
- Creative high school courses are effective.
- It is essential to incorporate current societal problems in the curriculum.
<table>
<thead>
<tr>
<th>Creative high school courses are effective.</th>
</tr>
</thead>
<tbody>
<tr>
<td>It is essential to incorporate current societal problems in the curriculum.</td>
</tr>
<tr>
<td>Success in college is associated with better writing skills.</td>
</tr>
<tr>
<td>Creative high school courses are unusual.</td>
</tr>
<tr>
<td>Curriculum should be based on the methodologies of inquiry in sciences.</td>
</tr>
<tr>
<td>Creative high school courses are successful.</td>
</tr>
<tr>
<td>More hours of group study are related with lower course grades in college.</td>
</tr>
<tr>
<td>Creative high school courses are affordable.</td>
</tr>
<tr>
<td>---------------------------------------------</td>
</tr>
<tr>
<td>A curriculum should be organized around the fundamental concepts of a subject matter.</td>
</tr>
<tr>
<td>Success in college is associated with advanced parental education.</td>
</tr>
<tr>
<td>Creative high school courses are original.</td>
</tr>
<tr>
<td>Affective, cognitive, and psycho-motor development should be integrated in a curriculum.</td>
</tr>
<tr>
<td>Creative high school courses are novel.</td>
</tr>
<tr>
<td>Success in college is related to higher self-esteem.</td>
</tr>
<tr>
<td>Creative high school courses are implementable.</td>
</tr>
<tr>
<td>A curriculum should address learners' needs in a technological world.</td>
</tr>
<tr>
<td>Creative high school courses are unique.</td>
</tr>
<tr>
<td>Success in college is related to higher levels of motivation.</td>
</tr>
<tr>
<td>Creative high school courses are imaginative.</td>
</tr>
<tr>
<td>The priority in curriculum design is to develop students' understanding of theories.</td>
</tr>
<tr>
<td>More work/study hours are related to lower course grades in college.</td>
</tr>
<tr>
<td>Creative high school courses are goal-directed.</td>
</tr>
<tr>
<td>-----------------------------------------------</td>
</tr>
<tr>
<td>Curriculum design should focus on effective teaching methods that accomplish objectives.</td>
</tr>
<tr>
<td>Creative high school courses are feasible.</td>
</tr>
</tbody>
</table>
Need For Cognition Scale

Drag the slider to indicate how much each of the statements below is characteristic of you.

<table>
<thead>
<tr>
<th>Not Very</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>Very Much</th>
</tr>
</thead>
<tbody>
<tr>
<td>I would prefer complex to simple problems.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I like to have the responsibility of handling a situation that requires a lot of thinking.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thinking is not my idea of fun.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I would rather do something that requires little thought than something that is sure to challenge my thinking abilities.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I try to anticipate and avoid situations where there is likely a chance I will have to think in depth about something.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
I find satisfaction in deliberating hard and for long hours.

I only think as hard as I have to.

I prefer to think about small daily projects than long-term ones.

I like tasks that require little thought once I have learned them.

The idea of relying on thought to make my way up to the top appeals to me.

I really enjoy a task that involves coming up with new solutions to problems.

Learning new ways to think doesn't excite me very much.
<table>
<thead>
<tr>
<th>I prefer my life to be filled with puzzles that I must solve.</th>
</tr>
</thead>
<tbody>
<tr>
<td>The notion of thinking abstractly is appealing to me.</td>
</tr>
<tr>
<td>I would prefer a task that is intellectual, difficult, important to one that is somewhat important but does not require much thought.</td>
</tr>
<tr>
<td>I feel relief rather than satisfaction after completing a task that required a lot of mental effort.</td>
</tr>
<tr>
<td>It's enough that something gets the job done. I don't care how or why it works.</td>
</tr>
<tr>
<td>I usually end up deliberating about issues even when they do not affect me personally.</td>
</tr>
</tbody>
</table>
APPENDIX D

PROBLEM SCENARIO

Please read the following problem scenario.

DESIGNING A NEW HIGH SCHOOL COURSE

You have recently been hired as a new teacher in a town called Imlay City. You were hired directly out of college and have the summer to prepare your courses. The high school is in a very nice area of Pennsylvania and pays better than nearly all other high schools in the state. The high school contains about 600 students or about 150 per grade. The high school population is comprised of roughly 55% females and 45% males. The demographics are predominately Caucasian (89%) with some African-Americans (5%) and Hispanics (6%).

The Situation At Imlay High School

As with most high schools, a large proportion of Imlay City's graduates are attending college (70%), though this number is slightly below the national average (77%). Because of this slight discrepancy, the principal of your new school examined the statistics of Imlay City graduates attending college. In the midst of her search, the principal found that Imlay City graduates were dropping out of college at a rate greater than the national average. Specifically, the national percentage of college freshman dropouts is 30%. In comparison, Imlay City's freshman dropout rate is a staggering 50%. Moreover, a survey of five other local schools revealed dropout percentages of 10%, 11%, 9%, 6%, and 12%, respectively.

The Survey Results About The High School Graduates' College Experience

The alarming trend lead the principal to search for an explanation of these numbers. She sent out a survey to past high school graduates, asking them for feedback on their college experience. The responses to the survey indicated that those students who did not drop out of school their freshman year reported a great deal of difficulty that first year. Moreover, they indicated that the only way they survived the first semester was by adopting new patterns of behavior substantially different from those learned in Imlay City. Even more startling was that those individuals who did not drop out their freshman year indicated very clearly that they were overwhelmed by college life and were simply not ready for it. The results of the survey lead the principal to a single solitary conclusion: Imlay City graduates were not prepared for college.

Your Task: Design A New College Prep Course

A week after being hired, the principal has called you into her office for a very important meeting. She informs you that because you are a recent college graduate who came so highly recommended, you have been selected to teach a very important new course at Imlay City, the senior college prep course. The new class will be mandatory for all seniors and they must pass the course with a “C” or better in order to graduate. This will be the only course you teach and each class will contain about 30 students.

In her description of the requirements for the course, the principal makes one point very clear, the senior college prep course needs to be a creative high school course designed to prepare high school students for college. She emphasized that you need to take a creative approach in designing and teaching the course. The principal has asked you to 1) identify the overall goal of your course and 2) list and describe the specific learning activities that you will include in the course.

Please, follow the instructions below to complete these two tasks.
APPENDIX E

Problem Solving and Reflective Tasks

Please, identify the overall goal of your creative high school course.

Please, both list and describe the specific learning activities of the creative high school course that you will propose as a potential creative solution.

Please, provide an explanation of your creative high school course to the school board members.
Below you can see an Argumentation Vee Diagram (AVD). Read the directions within the diagram to help you fill in the columns below the diagram.

**QUESTION:** Is the proposed course a potentially creative high school course?

**REASONS**

On the left side of the diagram one can provide reason(s) why the course is a creative high school course. Enter your reasons in the **REASONS** column below.

**OBJECTIONS**

On the right side of the diagram one can write corresponding objection(s) or challenge(s) to the reasons. Enter potential objections to your reasons that the school board members may bring up, in the **OBJECTIONS** column below.

**INTEGRATE**

Directions to Integrate: Reread your reasons and corresponding objections. For each pair of reason and objection, click to show whether the reason or the objection is stronger.

### Table

<table>
<thead>
<tr>
<th>CREATIVE HIGH SCHOOL COURSE</th>
<th>CLICK to indicate whether the reason or objection is stronger</th>
<th>CREATIVE HIGH SCHOOL COURSE</th>
</tr>
</thead>
<tbody>
<tr>
<td>REASONS</td>
<td>STRONGER REASON</td>
<td>STRONGER OBJECTION</td>
</tr>
<tr>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
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<tr>
<td>4</td>
<td></td>
<td></td>
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<tr>
<td>5</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
APPENDIX F

Solution Self-Evaluation Questionnaire

Once you have designed your creative college prep course, the principal has asked you to submit this questionnaire with your course plan of the teaching activities.

The principal has asked you to provide estimates of the degree to which your creative high school course meets the following characteristics. Drag the slider to indicate your estimates.

* Estimates that the creative high school course proposed is *

<table>
<thead>
<tr>
<th>Injection</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Not</td>
<td>Very</td>
<td></td>
<td>Very</td>
<td>Very</td>
</tr>
<tr>
<td>Effectec</td>
<td></td>
<td></td>
<td></td>
<td>Very</td>
<td>Very</td>
</tr>
<tr>
<td>Likable</td>
<td></td>
<td></td>
<td></td>
<td>Very</td>
<td>Very</td>
</tr>
<tr>
<td>Affordable</td>
<td></td>
<td></td>
<td></td>
<td>Very</td>
<td>Very</td>
</tr>
<tr>
<td>Implementable</td>
<td></td>
<td></td>
<td></td>
<td>Very</td>
<td>Very</td>
</tr>
<tr>
<td>Original</td>
<td></td>
<td></td>
<td></td>
<td>Very</td>
<td>Very</td>
</tr>
<tr>
<td>Vogue</td>
<td></td>
<td></td>
<td></td>
<td>Very</td>
<td>Very</td>
</tr>
<tr>
<td>Cost-Effective</td>
<td></td>
<td></td>
<td></td>
<td>Very</td>
<td>Very</td>
</tr>
<tr>
<td>Novel</td>
<td></td>
<td></td>
<td></td>
<td>Very</td>
<td>Very</td>
</tr>
<tr>
<td>Possible</td>
<td></td>
<td></td>
<td></td>
<td>Very</td>
<td>Very</td>
</tr>
<tr>
<td>Unique</td>
<td></td>
<td></td>
<td></td>
<td>Very</td>
<td>Very</td>
</tr>
<tr>
<td>Successful</td>
<td></td>
<td></td>
<td></td>
<td>Very</td>
<td>Very</td>
</tr>
<tr>
<td>Ready</td>
<td></td>
<td></td>
<td></td>
<td>Very</td>
<td>Very</td>
</tr>
<tr>
<td>Organized</td>
<td></td>
<td></td>
<td></td>
<td>Very</td>
<td>Very</td>
</tr>
<tr>
<td>Unusual</td>
<td></td>
<td></td>
<td></td>
<td>Very</td>
<td>Very</td>
</tr>
<tr>
<td>Imaginative</td>
<td></td>
<td></td>
<td></td>
<td>Very</td>
<td>Very</td>
</tr>
</tbody>
</table>
Coding Scheme Guidelines

The ideas that refer to **consequences or results** of the situations described in the two divergent thinking tasks are color coded. The pre-established coding scheme included three categories. I have expanded the coding scheme by adding two coding categories (i.e., elaboration and general). The five categories for coding the responses to each task are:

**Unique:** Any unique idea that addresses the task (Yellow)

**Duplicate:** Any duplicate of a previous idea (Green)

**Elaboration:** Any elaborative statement that explains a previous idea (Pink)

**General:** Any overly general idea (Light blue)

**Irrelevant:** Any irrelevant or misaligned idea with the task due to a misinterpretation of the task (Red)

Table 6.1

*Examples of Valid and Nonvalid Idea Units for the Divergent Thinking Tasks*

<table>
<thead>
<tr>
<th></th>
<th>Task I</th>
<th>Task II</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Valid</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unique</td>
<td>Grocery stores would close down.</td>
<td>Many new things would be invented.</td>
</tr>
<tr>
<td></td>
<td>We would have to find a new activity for social gatherings.</td>
<td>More accidents at night since people still awake but visibility still low.</td>
</tr>
<tr>
<td>Elaboration</td>
<td>Because restaurants are a big part of our economy.</td>
<td>Because you wouldn't have to sit down and eat.</td>
</tr>
<tr>
<td></td>
<td>I love eating food, therefore I would still eat.</td>
<td>People would take advantage of this invention.</td>
</tr>
<tr>
<td>General</td>
<td>Human population problem.</td>
<td>Economic effects would exist.</td>
</tr>
<tr>
<td></td>
<td>People would be more independent.</td>
<td>Attitudes would suffer.</td>
</tr>
<tr>
<td><strong>Nonvalid</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Duplicate</td>
<td>People would be more fit (more in shape)</td>
<td>More work would get done (more productive)</td>
</tr>
<tr>
<td>Irrelevant</td>
<td>Could die without food in their system.</td>
<td>Become more cranky.</td>
</tr>
<tr>
<td></td>
<td>People would drastically lose weight.</td>
<td>Our bodies would not have time to restore.</td>
</tr>
</tbody>
</table>
Assumptions and Decision-Making Rules

1) Given that the directions prompted individuals to list consequences and results individuals are not penalized if they provide short, brief, succinct responses and some degree of inference is acceptable.

2) Examples count as the unique ideas but any explanations or general statements about the examples are coded as elaborations. Repetitions of identical examples do not count as unique ideas but they are duplicates.

3) Signifiers such as the words since, because, and therefore indicate elaboration.

4) Statements in which students think aloud, or attempt to interpret the task by explicating their assumptions such as this “Hopefully the invention would not make people lose a lot of weight and people would still be healthy”, or generate hypothetical if statements are coded as elaborations.

5) For the first task there are two acceptable assumptions 1) People could still eat if they want to and 2) People don’t necessarily need to eat to survive since with the intervention nutritional needs are met.

6) Statements that indicate misinterpretation of the task when people assume that the intervention could be fatal or that nutritional needs are not met include: malnutrition, starvation, death, lower world population; people would become too skinny, and body not functioning.

7) For Task II there are two acceptable assumptions 1) People could still sleep if they wanted and 2) People don’t necessarily need to sleep to be able to function well throughout the day because their needs for rest are met by the intervention.

8) Statements indicate misinterpretation of task II when students assume that the intervention would make them more tired and would not allow them to function properly. Statements that signify such misinterpretation of the task include fell asleep on the wheel, too tired to for life, more likely or less likely to work hard, get into accidents, people would not have as much energy, become less responsive.

9) In the following cases both ideas count as unique a) so many more things would get done (U) because people would have a lot more time on their hands (U); b) People would become more productive (U) as they would not require work breaks for meal (U).

10) In the following case these are two similar ideas not unique, thus one is the duplicate of the other “then people would be a lot more productive (U) and get a lot more work done (D)”
CODING GUIDE FOR THE PROBLEM SOLVING TASK

**Guidelines:** These are general guidelines for coding the responses to the problem solving scenario and specifically the prompt given to the participants to list and describe the specific learning activities of their course. Specific decision rules for some categories are provided in the coding scheme table that follows.

1) **A learning activity** is any learning experience either enactive (i.e., through actual doing) or vicarious (i.e., students observe or listen to models perform) designed for the learners to attain an instructional goal such as the acquisition of information, knowledge, skills, attitudes and strategies. A distinct activity that the learner engages in which can be physical or mental.

2) If a statement is an elaboration, paraphrase, or restatement then it will not be coded as a different task-relevant unit. A statement is coded as task-relevant unit when it provides unique, new information.

3) A statement represents a learning activity when it can be rephrased or restated with a verb describing what actions student will be engaged in.

4) A statement will be assigned to the learning goals/objectives category when it describes what students will learn or be able to do (e.g., the students learn how to communicate effectively and how to make friends). Such statements are broad and vague and you are unable to identify a verb that describes what the student is engaged in.

5) A statement doesn’t constitute a valid task-relevant unit when it is overly general or when there is no verb relevant to the student in the statement (e.g., help them with their essays for application, teach the kids that they need to study).

6) A statement which refers to “teaching how to” perform a skill or complete a procedure is coded under modeling (instructor).

7) When a statement provides information about the structure or the organization of the course or of an activity along with the description of the activity then it is broken down to two task-relevant units and it is assigned two codes: 1) course structure and a 2) learning activity code.

8) If a phrase includes a general/overarching statement (e.g., multiple writing assignments) followed by specific examples then each example receives a code instead of a single code for the general statement.

9) When a proposed activity is referred to as group work or team work without any description of the task that students will complete it is coded as an academic simulation category.

10) A response that has only vague, broad, irrelevant or uncodable task-relevant units is excluded from the dataset.
Table 6.2

*Coding Scheme for the Responses to the Problem Solving Scenario*

<table>
<thead>
<tr>
<th>THEME</th>
<th>OVERARCHING CATEGORIES</th>
<th>CODING CATEGORIES</th>
<th>CATEGORY DESCRIPTIONS, DECISION RULES &amp; EXAMPLES</th>
</tr>
</thead>
</table>
| LEARNING ACTIVITIES | DISCUSSION (1)           | 1. STUDENT DISCUSSION: A student discussion includes any discussion among students in which the instructor can be involved or not. There are 3 types of student discussion.  
1.1 Task Specific  
1.2 Analytical/Reflective  
1.3 Debates  
1.4 General term | Task specific: Discussion about a task that students have completed or need to complete.  
Ex: (Have students present their course of action to the class) then discuss the best options.  
Analytical/Reflective: Discussion with the purpose to analyze or reflect on a topic or experience  
Ex: Discussing different majors and options when entering into college.  
Debates: Students are assigned in two groups and are asked to debate about an issue.  
Ex: Having debates about modern issues. |
|                |                         | 2. OTHER DISCUSSION: Any discussion or interaction with other individuals not peers.  
2.1 Experts  
2.2 Novices | Students have a discussion with individuals who are more experts than them (e.g., specialists).  
Ex: Speak to counselors to expose students to the expectations of colleges.  
Students have a discussion with novices who are somewhat more knowledgeable than them (e.g., college grads). |
| WARM UP ACTIVITIES (2) |                       | 3. BRAIN STORMING or pre-writing | Brainstorming activities that prepare students for a discussion or writing.  
Ex: Learn new study habits through group brainstorm sessions. |
<table>
<thead>
<tr>
<th>THEME</th>
<th>OVERARCHING CATEGORIES</th>
<th>CODING CATEGORIES</th>
<th>CATEGORY DESCRIPTIONS, DECISION RULES &amp; EXAMPLES</th>
</tr>
</thead>
<tbody>
<tr>
<td>LEARNING ACTIVITIES</td>
<td>INSTRUCTOR LED (3)</td>
<td>4. GUEST SPEAKERS</td>
<td>Ex: Bring in interesting guest speakers for all of the different occupations that they are interested in.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5. LECTURE</td>
<td>Informational: The instructor provides information through mainly explanations or examples.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5.1 Informational</td>
<td>Ex: Give an overview of all the changes they will face in college, roommate situations, partying, etc.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5.2 Reflective</td>
<td>Reflective: The instructor reflects on his/her experiences through a lecture.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5.3 General term</td>
<td>Ex: Talk about my experience in college. Tips for success.. Getting involved…</td>
</tr>
<tr>
<td></td>
<td></td>
<td>6. MODELING</td>
<td>Instructor: The instructor provides cognitive modeling</td>
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<tr>
<td></td>
<td></td>
<td>6.1 Instructor</td>
<td>Ex: Showing students the best way to read a college textbook</td>
</tr>
<tr>
<td></td>
<td></td>
<td>6.2 Other models</td>
<td>The process of providing support and gradually removing it so that a learner can perform a task.</td>
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<tr>
<td></td>
<td></td>
<td>7. SCAFFOLDING</td>
<td>Ex: The teacher will help the students at the beginning of the year, but as the year goes on, teachers should remind their students less and less until they are organizing their time without the help of anyone else.</td>
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<tr>
<td></td>
<td></td>
<td>8. WORKSHOPS</td>
<td>Class is organized as a workshop for a specific purpose (e.g. writing, technology).</td>
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<tr>
<td></td>
<td></td>
<td>9. ACADEMIC PROBLEM SOLVING (4)</td>
<td>The process of trying to achieve a goal for which there is not an automatic solution (Jonassen, 2000) in the context of an academic subject or topic.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>10. DECISION MAKING</td>
<td>Students make a decision about a course of action by selecting an option from a set of alternatives after evaluating the alternatives. When students get assigned multiple things and they need either to complete them or decide how to go about doing them.</td>
</tr>
<tr>
<td></td>
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<td></td>
<td>Ex: This fundraiser is entirely the students. Overall, the program will allow students to make decisions based on the main concept.</td>
</tr>
<tr>
<td>THEME</td>
<td>OVERARCHING CATEGORIES</td>
<td>CODING CATEGORIES</td>
<td>CATEGORY DESCRIPTIONS, DECISION RULES &amp; EXAMPLES</td>
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<td>----------------------------------------------------</td>
</tr>
<tr>
<td>LEARNING ACTIVITIES</td>
<td>EXPERIENTIAL LEARNING (5)</td>
<td>11. EXPERIMENTS</td>
<td>Ex: Then we will test out our brainstorming list through group experiments to see which method of studying is the most effective.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>12. PROJECTS</td>
<td>Ex: Learn how to manage time through a fun project.</td>
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<td></td>
<td></td>
<td>13. STUDENT PRESENTATIONS</td>
<td>Ex: Have them do a presentation to the class about the school they are going to.</td>
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<td>14. PRACTICE</td>
<td>Ex: Practice stress relieving techniques.</td>
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<tr>
<td></td>
<td></td>
<td>15. EXTRACURRICULAR ACTIVITIES</td>
<td>Ex: I will have the students attend several extracurricular activities for credit.</td>
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<tr>
<td></td>
<td></td>
<td>16. FIELDTRIPS</td>
<td>Visits and attendance of events out of school. Ex: Visit local colleges, tour campuses.</td>
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<tr>
<td></td>
<td></td>
<td>17. CAMPUS STAY</td>
<td>Ex: A weeklong trip to a college where students actually live in dorms.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>18. CLASSROOM OBSERVATION</td>
<td>Ex: Take my students to a nearby college so they can sit in on a class.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>19. COMMUNITY BASED LEARNING</td>
<td>Any instance of learning, service, &amp; collaboration with the community. Ex: Doing service projects around the area of the school and helping others.</td>
</tr>
<tr>
<td></td>
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<td>20. GAMES</td>
<td>Ex: I would do some sort of money/spending game with students.</td>
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<td></td>
<td></td>
<td>21. ROLE-PLAY</td>
<td>Ex: Role-play different situations they might find difficult in college</td>
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<tr>
<td></td>
<td></td>
<td>22. SIMULATIONS</td>
<td>Students are put in a situation real life or academic that simulates (models) potential future situations (NOT simply a process) they will encounter (includes mock, trials, hands on.) Ex: I will have students work in pairs or groups frequently so that they will feel comfortable interacting with others. Ex. Have them print out the map of their campus and find the places.</td>
</tr>
</tbody>
</table>

22.1 Academic/Career
22.2 Everyday
<table>
<thead>
<tr>
<th>THEME</th>
<th>OVERARCHING CATEGORIES</th>
<th>CODING CATEGORIES</th>
<th>CATEGORY DESCRIPTIONS, DECISION RULES &amp; EXAMPLES</th>
</tr>
</thead>
<tbody>
<tr>
<td>LEARNING ACTIVITIES</td>
<td>RESEARCH (6)</td>
<td>23. ACADEMIC</td>
<td>Research on assigned academic relevant topics. Ex: Put them in groups and have them do research on college course topics.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>24. CAREER</td>
<td>Research on career resources Ex: Have students do a lot of research into different career paths and goals.</td>
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<tr>
<td></td>
<td></td>
<td>25. COLLEGE</td>
<td>Research on colleges, campuses, college life, and available resources Ex: Looking into the many clubs and activities offered at schools and how to get involved.</td>
</tr>
<tr>
<td>WRITING ASSIGNMENTS</td>
<td>26. EXPOSITORY</td>
<td>26.1 EXTENDED (e.g., papers or essays)</td>
<td>Ex: Writing a research paper with sources on any topic that interests them. From the notes they take in class, they will have to go home and write a more detailed summary.</td>
</tr>
<tr>
<td>(7)</td>
<td></td>
<td>26.2 BRIEF (e.g., summaries or reports)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>27. PERSUASIVE</td>
<td>Ex: They will research certain topics and write a paper about their college. (e.g., persuasive essays or book reviews)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>28. JOURNALING or REFLECTIONS</td>
<td>Writing journals, reflections or activity logs.</td>
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<td></td>
<td></td>
<td>29. PERSONAL (e.g. resume)</td>
<td>Ex: Resume 101: how to build a resume.</td>
</tr>
<tr>
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<td></td>
<td>30. CREATIVE (e.g., narratives, poems)</td>
<td>Ex: Writing narratives about fiction stories.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>31. ORGANIZATIONAL AID (e.g. chart, diagram)</td>
<td>Ex: Have the students fill out a time management chart for a week.</td>
</tr>
<tr>
<td>THEME</td>
<td>OVERARCHING CATEGORIES</td>
<td>CODING CATEGORIES</td>
<td>CATEGORY DESCRIPTIONS, DECISION RULES &amp; EXAMPLES</td>
</tr>
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<td>---------------------------------------------------</td>
</tr>
<tr>
<td>LEARNING ACTIVITIES</td>
<td>WRITING ASSIGNMENTS (7)</td>
<td>32. NOTE-TAKING</td>
<td>Any guided (with a note-taking aid: such as an outline) or unguided note-taking instance. Ex: I will give the students “college lectures” and “college reading” and guide them through taking effective notes.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>33. UNSPECIFIED</td>
<td>Only the term writing assignments is used Ex: Writing assignments will be given in respect to more college like writing styles</td>
</tr>
<tr>
<td>READING ASSIGMENTS (8)</td>
<td>34. TEXTBOOKS</td>
<td></td>
<td>Ex: This will require reading of the text alone as well as studying and defining meanings from the text</td>
</tr>
<tr>
<td></td>
<td>35. OTHER TYPES OF BOOKS</td>
<td></td>
<td>Ex: Contemporary books for students to read.</td>
</tr>
<tr>
<td>ASSESSMENT</td>
<td>36. ARTICLES or REPORTS</td>
<td></td>
<td>Ex: Students will need to find an online database, or newspaper/ magazine article.</td>
</tr>
<tr>
<td>SUMMATIVE (9)</td>
<td>37. TESTING</td>
<td></td>
<td>Any testing occasion. When students mention different types of tests such as multiple choice and essay test each one counts as a testing occasion. When students mention testing at the beginning and end of the semester only 1 testing code is assigned because beginning and end of semester refer to the course structure. Ex: By having midterms in the class.</td>
</tr>
<tr>
<td>FORMATIVE (10)</td>
<td>38. HOMEWORK ASSIGNMENTS</td>
<td></td>
<td>Ex: Students will be given homework over the internet.</td>
</tr>
<tr>
<td></td>
<td>39. SELF-EVALUATION</td>
<td></td>
<td>Ex: At the end of the course the students will evaluate themselves.</td>
</tr>
<tr>
<td></td>
<td>40. PEER REVIEW</td>
<td></td>
<td>Any occasion in which a student evaluates or provides feedback to the work of a classmate. Ex: I would teach peer review/working in groups collaboratively.</td>
</tr>
<tr>
<td>DIAGNOSTICS (11)</td>
<td>41. SURVEY</td>
<td></td>
<td>Any assessment conducted so that the instructor determines the prior knowledge, skills, and beliefs of a student. Ex: Career testing (taking an actual test to start the job search &amp; help with class selection)</td>
</tr>
<tr>
<td>THEME</td>
<td>OVERARCHING CATEGORIES</td>
<td>CODING CATEGORIES</td>
<td>CATEGORY DESCRIPTIONS, DECISION RULES &amp; EXAMPLES</td>
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<td>-----------------------------------------------</td>
</tr>
<tr>
<td>BEYOND LEARNING ACTIVITIES</td>
<td>INSTRUCTION /COURSE DESIGN ELEMENTS (12)</td>
<td>42. MATERIALS</td>
<td>Any type of materials that the instructor provides (e.g., brochure). Ex: The course will have general course material to prepare students for the various courses they will take.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>43. EDUCATIONAL TECHNOLOGIES</td>
<td>Any type of educational technology that the instructor uses. Ex: Other computer programs will frequently be used.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>44. LEARNING GOALS OR OBJECTIVES</td>
<td>The statement defines a learning goal or objective. Ex: They will then learn to study all material and decipher what material is necessary for tests.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>45. SYLLABUS</td>
<td>Provision of a syllabus by the instructor.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>46. COURSE STRUCTURE OR SCHEDULE</td>
<td>A description of how the instructor is setting up the structure and organization of the course or of the activity.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>47. LEARNING ENVIRONMENT</td>
<td>A description of the environment climate for learning. Ex: Encourage them to be involved in high school</td>
</tr>
</tbody>
</table>
CODING GUIDE FOR EFFECTIVENESS OF LEARNING ACTIVITIES

Guidelines for scoring valid task-relevant units for their effectiveness:

1. The effectiveness of a learning activity or other valid task-relevant unit (i.e., instruction/course design element) is operationalized as the degree to which the learning activity or other design element addresses the problem (direction) and the degree to which a learning or assessment activity aligns with the overall goal of the course (alignment).

2. A learning activity or other valid task-relevant unit aligns well with a goal when it is appropriate to attain the goal. For example tasks that are authentic and simulate or resemble the abilities, skills, and strategies that the instructor wants to develop are strongly aligned. However, when a task is vaguely described as teach, explain or discuss something then it is scored as weakly aligned with the goal.

3. When the idea unit represents a learning goal or a learning objective than a learning activity then it is assigned a code 9. A statement is assigned to the learning goal category when it describes what students will learn or be able to do (e.g., the students learn how to communicate effectively and how to make friends). Such statements are broad and vague and you are unable to identify a verb that describes what the student is engaged in.

4. Any assessment activity including testing is considered to be a learning activity.

5. When a task-relevant unit is an attempt to simulate the college experience or environment or situation then is considered to provide information or raising familiarity with the college experience and environment.

Decision Making Rules for Scoring

1. It is assumed that participants design a high school course to prepare students for a college similar to the Pennsylvania State University.

2. The information, knowledge, abilities, skills or strategies vary in terms of their importance for success in college and for smooth transition to college. These are the types of information, knowledge, abilities, skills and strategies drawn from the entire data set and how they were categorized:

   • Important: Reading ability, writing skills, study skills (include organizational skills), note taking skills, decision making ability, test taking strategies, critical thinking (including problem solving), self-regulation, coping strategies (e.g., stress management; help-seeking), interpersonal (social)
skills, cooperative learning skills, time and budget management skills, technology knowledge and skills, campus information.

- **Somewhat important:** Presentation skills, research skills, citing sources, social problem solving, information or familiarity with the college experience (lifestyle, environment, structure), knowledge about higher education, career decision making & preparation, personal care/independent living skills.

3. If a learning activity is vaguely expressed as targeting problems/issues without specifying what types of problems they are referring to then it is considered to target college experience.

4. When the activity involves guest speakers or interviews with students then assume that they share important information and knowledge.
## APPENDIX H

### LIST OF VARIABLES

Table 6.3

*The Variables Entered for Data Analyses (n=103)*

<table>
<thead>
<tr>
<th>Variables</th>
<th>M(SD)</th>
<th>Possible Range</th>
<th>Actual Range</th>
<th>Reliability Coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>Divergent Thinking</td>
<td></td>
<td></td>
<td></td>
<td>$\alpha_{\text{K} \alpha} = .63$</td>
</tr>
<tr>
<td>Divergent Thinking (I)</td>
<td>6.11(2.42)</td>
<td>-</td>
<td>1-13</td>
<td>-</td>
</tr>
<tr>
<td>Divergent Thinking (II)</td>
<td>5.52 (2.22)</td>
<td>-</td>
<td>1-14</td>
<td>-</td>
</tr>
<tr>
<td>Need for Cognition</td>
<td>48.47(10.46)</td>
<td>0-90</td>
<td>15.1-72.9</td>
<td>$\alpha = .79$</td>
</tr>
<tr>
<td>Beliefs about Creative Outcomes</td>
<td>26.89(7.29)</td>
<td>0-45</td>
<td>6.7-44.2</td>
<td>$\alpha = .87$</td>
</tr>
<tr>
<td>Relevant Coursework</td>
<td>1.59(.93)</td>
<td>-</td>
<td>1-5</td>
<td>-</td>
</tr>
<tr>
<td>Solution Creativity</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average Originality</td>
<td>0.90 (0.09)</td>
<td>0-1</td>
<td>0.44-0.99</td>
<td>-</td>
</tr>
<tr>
<td>Average Effectiveness</td>
<td>3.23 (0.59)</td>
<td>0-4</td>
<td>0-4</td>
<td>-</td>
</tr>
<tr>
<td>Solution Self-Evaluation</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Originality Self-Evaluation</td>
<td>18.96(6.73)</td>
<td>0-35</td>
<td>2.6-30.0</td>
<td>$\alpha = .87$</td>
</tr>
<tr>
<td>Effectiveness Self-Evaluation</td>
<td>26.69(5.38)</td>
<td>0-35</td>
<td>7.2-35.0</td>
<td>$\alpha = .88$</td>
</tr>
</tbody>
</table>
Bibliography


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EDUCATION

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Bachelor of Arts Education (06/2004)
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Thesis title: Creativity and its development during childhood.

SCHOLARLY PUBLICATIONS


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Andiliou, A. & Brunow, B. (2011, October). E-portfolios as reflective and collaborative tools for faculty developers. Interactive 75-minute workshop. Joint Professional and Organizational Development (POD)/Historically Black Colleges and Universities Faculty Development Network (HBCUFDN) Conference, Atlanta, GA.
