IS COLLABORATION A NECESSARY COMPONENT OF PROBLEM-BASED LEARNING?

by

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ABSTRACT OF THE DISSERTATION

Is Collaboration a Necessary Component of Problem-Based Learning?

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The instructional method of problem-based learning (PBL) has continued to grow in popularity among educators at all levels despite a lack of definitive empirical support for its use. To date, research findings documenting positive outcomes associated with PBL have been largely insufficient in addressing many of the concerns raised by critics of the method. Specifically, many of the studies in problem-based learning to this point have involved an absence of experimental control and/or the presence of significant methodological flaws, both of which have drawn the criticism that the collective body of research related to the efficacy of PBL suffers from a general lack of validity (Colliver, 2000; Savery, 2006).

The current study involved a component analysis of problem-based learning conducted in an authentic learning environment. This research sought to answer the following questions: What is the influence of positive interdependence within groups on student performance in PBL? What is the influence of the social aspect of group work on student performance in PBL? What is the influence of PBL instructional designs on the development of skills needed for successful collaboration?

A crossed, within-subjects design was used to compare the academic performance of students across three experimental conditions within the context of three sections of an undergraduate Educational Psychology course. The three conditions included PBL-Positive

Interdependence, PBL-High Positive Interdependence, and PBL-Independent. The instructor, course content, instructional time, and course materials were controlled to ensure consistency across the three sections.

The results of the current study suggest that the collaborative aspect of PBL is essential to the success of students engaged in this form of instruction. Additionally, the findings of the current study suggest that student success in collaborative learning environments may rely on the existence of adequate structure to scaffold the students' development of skills related to the collaborative process. The findings of the current study confirm that PBL is most effective when implemented in its purest form, and that problem-based instructional designs without a collaborative component cannot be considered as a pedagogically equivalent alternative to problem-based learning as it is commonly defined.

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CHAPTER I
INTRODUCTION

> …the central problems with American education are not pedagogical or organizational or social or cultural in nature but are fundamentally *political.* That is, the problem is not that we do not know how to make schools better but that we are fighting among ourselves about what goals schools should pursue. (Labaree, 1997, p.40)

Despite a vast amount of research focusing on the development and identification of pedagogical "best practices" within the field of education, there continues to be a significant amount of debate among educational researchers as to how the curriculum in American schools should be designed and implemented. Specifically, a great deal of theory development and experimental research has sought to advance current beliefs related to which instructional outcomes are of utmost importance, how these outcomes should be measured, and how we should teach in order to encourage students to meet related objectives. Several researchers have often proposed different, and in some cases, conflicting arguments as to which forms of instruction are most appropriate in nurturing the most desirable student outcomes. One such debate exists between proponents of Problem-based Learning (Schmidt, Loyens, Van Gog, & Paas, 2006; Hmelo-Silver, Duncan, & Chinn, 2006), and those that support a more structured and direct approach to learning informed by Cognitive Load Theory (Kirschner, Sweller, & Clark, 2006).

While instructional methods utilizing a Problem-based Learning (PBL) approach can vary across several dimensions of their design, PBL generally involves empowering students to take ownership of their education through their engagement with ill-defined problems (Barrows, 1986). In PBL, the problem is typically presented in the form of a case that requires students to collaborate with peers in order to consider multiple avenues of approach towards the formulation of a viable solution. Positive instructional outcomes associated with PBL include: flexible

knowledge, problem solving skills, skills of self-directed learning, skills for effective collaboration, and intrinsic motivation (Hmelo-Silver, 2004).

Cognitive load theory (CLT) suggests that individuals have a finite capacity relative to their ability to engage in problem solving (Sweller, 1988). Proponents of this perspective argue that the presence of factors that are extraneous to the acquisition of academic content can result in an increased cognitive load representing a barrier to successful learning (Kirschner et al., 2006; Sweller, Kirschner, & Clark, 2007). These researchers maintain that providing students with worked examples that explicitly demonstrate the correct path toward a problem solution ultimately results in positive learning outcomes by lessening the cognitive load required to process the information (Kirschner et al., 2006). From this perspective the development and rehearsal of skills related to collaboration, self-directed learning, and the application of knowledge to novel situations is considered extraneous to the central task of the acquisition and retention of fact-based academic content (Sweller et al., 2007).

The fundamental disagreement between the proponents of problem-based learning and cognitive load theory relate to whether PBL is an effective means of instruction that is compatible with the cognitive structures of human learners. This debate seems to be due at least in part to a lack of consensus as to which educational outcomes are the most important to promote, as well as a narrow focus on juxtaposing only the most extreme examples of instruction informed by either perspective (Kuhn, 2007; Loyens & Gijbels, 2008). Proponents of instruction informed by CLT are primarily interested in measuring concrete domain-specific outcomes via traditional academic assessment while proponents of PBL are interested in promoting a variety of skills within the realms of higher order thinking, social interaction, and self-directed learning (SDL), in addition to outcomes related to the acquisition of domain-specific content. In PBL,

there is never one route to a single correct solution, whereas instructional strategies informed by CLT emphasize the importance of worked examples.

Advocates of instruction derived from CLT (Kirschner et al., 2006) argue that several of the fundamental characteristics of problem-based learning, and other instructional strategies that they collectively refer to as "minimally guided", render the approaches ineffective and incompatible with human cognitive architecture. Several recent studies have produced findings that suggest that in addition to encouraging the development of skills related to life-long learning, PBL results in outcomes related to domain-specific knowledge that are comparable or superior to those achieved via a traditional lecture/discussion instructional format (Beachey, 2007; Capon & Kuhn, 2004; Kaufman & Mann, 1999; McParland, Noble, & Livingston, 2004; Schmidt, Vermeulen, & van der Molen, 2006; Pease & Kuhn, 2010; Wirkala & Kuhn, 2011; Yadav, Subedi, Lundeberg, & Bunting, 2011). While there is empirical support for the use of problem-based learning as an alternative to traditional models of direct instruction, there has been little research analyzing the specific components of PBL in order to determine those that are essential for achieving successful outcomes.

The current study sought to contribute to the collective understanding of how problem-based learning achieves its effects by addressing the specific concern raised by Sweller, Kirschner and Clark (2007) that the collaboration among members of a group that occurs during student-centered instructional designs like PBL "imposes costs in terms of cognitive load" (p.117) that can often function as an impediment to learning. This was accomplished via an examination of the influence of collaboration among members of small groups within PBL instructional designs towards the achievement of successful learning outcomes. An investigation as to whether the benefits of collaboration outweigh the costs associated with the adoption of

collaborative instruction is justified given the significant amount of resources that must be committed to the successful implementation of instructional designs of this type in comparison to more traditional teacher-directed forms of learning.

The current study builds upon a line of recent experimental research that has focused on the comparison of outcomes attained via the use of a PBL model of instruction to those that result from more traditional instructor-directed models (Bahar-Ozvaris, Cetin, Turan, & Peters, 2006; Beachey, 2007; Capon & Kuhn, 2004; Kaufman & Mann, 1999; McParland et al., 2004; Rideout et al., 2002; Pease & Kuhn, 2010; Schmidt et al., 2006; van Gog, Kester, & Paas, 2011; Wirkala & Kuhn, 2011; Yadav et al., 2011). In addition to comparing the outcomes of PBL to those resulting from other instructional methods, two of these studies (Pease & Kuhn, 2010; Wirkala & Kuhn, 2011), also conducted a component analysis related to the identification of the aspects of PBL that result in successful learning. The findings of both of these studies suggested that the social component of PBL is not essential to ensure successful learning outcomes among participants. The potential implications of these findings could be transformational in relation to the way in which educational researchers and practitioners define and implement problem-based learning.

The studies by Pease and Kuhn (2010) and Wirkala and Kuhn (2011) provide the model on which the methodology for the present study is based. Similar to these previous two studies, the current study sought to conduct a thorough component analysis of PBL in an authentic learning environment while maintaining strict experimental control. The present study expanded upon the previous research by strictly adhering to the definition of PBL offered by both Pease and Kuhn (2010) and Wirkala and Kuhn (2011) in that it will involve students engaging a problem "without preparatory study in the subject matter" (pgs.58/1157 respectively).

Additionally, the design of the current study extended previous research in that it allowed for an investigation of the implications of incorporating the principles of social interdependence theory within the design of learning environments that involve collaboration among group members in order to examine the influence of varying degrees of positive interdependence within small groups on learning outcomes. This portion of the investigation was accomplished through the implementation of a "team assessment", a strategy designed to promote a high degree of positive interdependence among members of small groups during PBL.

Lastly, the current study differed from previous research in the methods that were utilized for the collection and analysis of data towards the documentation of variability that existed in student performance across experimental conditions. Previous studies involving a component analysis of PBL (Pease & Kuhn, 2010; Wirkala & Kuhn, 2011) were limited to an examination of student performance on individual assessments following PBL instruction as a means of data collection for quantitative analysis. Like the previous studies, the present research also involved a quantitative analysis of participant performance on individual assessments designed to measure the outcomes resulting from the three experimental conditions. However, the current study builds upon previous research in that it also included an examination of the artifacts that participants produced during the problem solution phases for each experimental condition as a means of documenting any variability in student performance that was due to the influence of the independent variable "instructional design".

In addition to a statistical analysis related to the existence and source of variance that may occur between student performance during the three experimental conditions, the current research involved data collection to allow for future analyses following the mixed-method model demonstrated in Hmelo-Silver (2000). This will involve an in-depth examination of the social

artifacts that students produced during the problem solution phase for each condition. The student discussion that occurred during the experimental conditions involving group work will be examined via a qualitative discourse analysis aimed to identify indicators of the existence of high-quality collaboration, the acquisition of skills related to flexible learning and/or self-direction, or any other potential benefits of collaboration during problem-based learning that are not well-accounted for via traditional forms of assessment.

CHAPTER II
LITERATURE REVIEW

Origins of Problem-based Learning

PBL arose within institutions of medical education as an alternative to traditional didactic instructional methods in order to address concerns that this type of teaching contributed to the development of passive students without the capacity to engage in problem solving or critical thinking (Williams, 1992). Problem-based learning was first developed by the faculty of Health Sciences at McMaster University, a Canadian school of medicine, around 1965. The original model for PBL was inspired by the practice of using case studies as the basis for instruction in legal education (Schmidt, 1993). Approximately four years later, problem-based learning was adopted as the primary means of instruction at McMaster and the institution admitted the first group of medical students to be trained primarily via a PBL method (Barrows & Tamblyn, 1980; Schmidt, van der Molen, te Winkel, & Wijnen, 2009).

Since its conception at McMaster, PBL has been widely adopted by many institutions of medical education throughout several countries to the extent that some researchers have described the phenomenon as "a small revolution in the medical education community" (Norman & Schmidt, 1992, p. 557). Additionally, the prevalence of PBL in educational environments in general has expanded way beyond medical education across numerous disciplines, grade/age levels, and academic domains (Albanese, 2000; Savery, 2006; Schmidt et al., 2009).

Problem-based Learning Defined

From its inception PBL has never been intended to be a "cookie cutter" pedagogy complete with step-by-step instructions. A good PBL curriculum should be dynamic, complex, and ever-evolving much like the real-world problems the strategy is meant to approximate. The widespread popularity and prevalence of problem-based learning across disciplines and domains

has resulted in many variations, misapplications, and misconceptions (Maudsley, 1999; Savery, 2006). While "problem-based learning does not refer to a specific educational method" (Barrows, 1986, p.481), there remains a common understanding of the fundamental components that should be included. In general, problem-based learning is a student-centered instructional design in which individuals work collaboratively to direct their own learning while solving a complex problem that has more than one possible solution (Hmelo-Silver, 2004). The specific defining characteristics of PBL include that students go into the problem "cold" in that they are not given any prior exposure to academic content that is directly relevant for devising a viable problem solution, students must take ownership of their own learning, the problem format used during instruction must approximate real-world situations in that there are many plausible solutions, and the instructional design must involve collaboration among students as a means of replicating how problems are typically addressed in many contexts across professional disciplines (Hmelo-Silver, 2004; Savery, 2006).

Students in PBL environments are not able to fulfill the requirements of the instructional task simply by relying on prior knowledge as is typical in most forms of instructor-centered learning. Since the problem is not presented in explicit form, the students must first identify the salient aspects of the information provided by the instructor in order to define what the problem actually is. Then students must come to a conclusion related to the type of knowledge that will be required to address the problem and identify potential sources of this knowledge. From this point, students must continue to manage their own learning in coming to a consensus with the other members of their group as to how to best address the problem of interest given the information gained from their chosen sources (Hmelo & Evensen, 2000; Hmelo-Silver, 2004; Savery, 2006; Schmidt et al., 2009).

The Instructor as a Facilitator in PBL

The role of the instructor in a PBL environment is not to be the sole source of knowledge in the classroom. Instead, the successful implementation of PBL requires that the instructor assume the role of a facilitator or tutor whose purpose is to guide students through the learning process. When preparing instructors to direct teacher-centered approaches it is common for the emphasis to be on nurturing the prospective instructor's acquisition of expertise in the particular content area to be taught. Although content area expertise remains important for the facilitator of PBL environments, it is not the most important characteristic that they must possess. This is nicely summed by Hmelo-Silver & Barrows (2006) by the statement that "In PBL the facilitator is an expert learner, able to model good strategies for learning and thinking, rather than provide expertise in a particular content" (p.24).

While students do not typically acquire content-specific expertise directly from the PBL facilitator, it is still important for the facilitator to have expertise in the targeted content area in order to aid students in appropriately managing their own learning. A facilitator that possesses expertise in both the processes of learning and in the content area of interest is able to effectively recognize when it is most appropriate to provide support and in what form. This dual expertise also allows a facilitator to recognize when it would be most beneficial for students to work without instructor guidance. One of the primary goals of the expert PBL facilitator should be to gradually fade their involvement in the learning process while scaffolding the abilities of their students to manage their own learning. This results in a gradual shift of the responsibility for learning from the facilitator to the individual students (Hmelo-Silver & Barrows, 2006).

In addition to having expertise related to the specific content area of interest and the nature of individual and collaborative learning processes, a master-facilitator of problem-based

learning environments must be intimately familiar with the primary learning outcomes that PBL is inherently suited to promote. Ideally, students participating in PBL become knowledgeable in a particular discipline while simultaneously acquiring effective problem-solving skills, the ability to self-direct their own learning, the ability to contribute to collaborative groups, and the motivation to learn for the enjoyment of doing so (Hmelo-Silver, 2004).

Theoretical Framework Underlying PBL

Constructivist theories of learning provide the foundation for all problem-based learning environments. The term constructivism is very broad in scope in that it has come to have many meanings and refers to numerous instructional methods depending on the philosophical perspective from which it is being described. Regardless of philosophical perspective, the foundation of constructivist theories of learning is that they refer to the ways in which people are active agents in constructing meaning through their interaction with their environment (Loyens & Gijbels, 2008).

Cognitive-constructivist theories suggest that the manner in which PBL achieves its goals is through encouraging students to form flexible mental models of their world by activating prior knowledge and comparing what is known to new models proposed via collaborative engagement towards achieving a problem solution (Schmidt, et al., 2009). While discussion and collaboration among students is important from cognitive views of problem-based learning, the emphasis is largely placed upon the activation and elaboration of individual students' prior knowledge in order to "build a context-sensitive cognitive structure of the processes, principles or mechanisms underlying the visible phenomena" (Schmidt, 1993, p.428). From this perspective, group discussion of the problem in PBL serves as a means of supporting this primary goal.

Social-constructivist theories suggest that learning involves the development of knowledge through a process of interaction, negotiation, and collaboration between individuals in their environment (Palincsar, 1998). From the social-constructivist view, learning in PBL environments involves many processes that parallel those described by cognitive-constructivists, such as the development of task representations (Goldman, 1991), and the refinement and utilization of skills related to higher order thinking (Palincsar, 1998). However, from this perspective the emphasis in PBL is placed primarily on the interactions between individuals as a means of achieving a collective understanding of the nature of the problem and its possible solutions. The social-constructivist perspective is a departure from traditional models of learning and teaching that focus on the acquisition and retention of fact-based information and situate the locus of knowledge building within the individual to one that focuses on more complex higher-order educational outcomes. Social-constructivist theories propose that these outcomes, related to an individual learner's ability to demonstrate flexibility, reasoning, and problem solving, are achieved via the collective knowledge "construction" that results from the interactions between individuals and between individuals and their environments (Palincsar, 1998).

In addition to contemporary theories of learning grounded within constructivism, the basis for the emphasis on meaningful problems in PBL can be attributed to the experiential educational theory and philosophy of John Dewey (Gijbels, Dochy, Van den Bossche, & Segers, 2005; Hmelo-Silver, 2004; Schmidt, 1993). Dewey (1938) suggests that:

> …every experience should do something to prepare a person for later experiences of a deeper and more expansive quality…But it is a mistake to suppose that the mere acquisition of a certain amount of arithmetic, geography, history, etc., which is taught and studied because it may be useful at some time in the future, has this effect, and it is a

> mistake to suppose that the acquisition of skills in reading and figuring will automatically constitute preparation for their right and effective use under conditions very unlike those in which they were acquired…Anything which can be called a study, whether arithmetic, history, geography, or one of the natural sciences, must be derived from materials which at the outset fall within the scope of ordinary life-experience (p.33)

Dewey's philosophy supports the argument made by proponents of PBL (Hmelo-Silver, 2004; Kuhn, 2007) that instruction should be situated within real-world contexts and that educators should aspire towards outcomes beyond the acquisition of rigid domain-specific knowledge for their students.

Cooperative Learning and Collaborative Learning Defined

While the terms "Cooperative" and "Collaborative" are often used interchangeably in educational literature to refer to instructional arrangements requiring that students work together to achieve some collective outcome, there are important distinctions between the two methods. Panitz (1997) provides a clear definition for each term, which serves to highlight these distinctions:

> Cooperation is a structure of interaction designed to facilitate the accomplishment of a specific end product or goal through people working together in groups. Collaboration is a philosophy of interaction and personal lifestyle where individuals are responsible for their actions, including learning, and respect the abilities and contributions of their peers. (p.1)

The primary operational distinction between cooperative learning and collaborative learning in a classroom environment relates to the degree to which a teacher imposes structure upon their students during instruction (Brufee, 1995). Specifically, in cooperative learning environments

"the teacher maintains complete control of the class, even though the students work in groups to accomplish a goal of the course", while in collaborative learning environments "groups would assume almost total responsibility for answering the question" (Panitz, 1997, p.1). For example, in a cooperative learning model the instructor might provide students with a specific task or question, and assign specific readings that provide the information students will need in order to work in small groups toward the completion of some well-defined objective. Alternatively, a facilitator of collaborative learning might provide students with a narrative case and then expect the students to be responsible for identifying/defining the actual problem, searching for and identifying appropriate sources of information, coming to a consensus within their groups about how to best address the problem, and collectively determining the most appropriate format for their finished product.

Despite the distinctions between the two approaches, Bruffee (1995) contends that they are not mutually exclusive in that "collaborative learning is designed to pick up where cooperative learning leaves off" (p.6). He argues that both approaches share the underlying principle of "helping students learn by working together on substantive issues" (p.1), and that it is the emphasis that each of the methods place on various outcomes that make them different (Brufee, 1995). From this perspective, students' engagement in cooperative learning instructional designs can serve as a vehicle for scaffolding the competencies required to successfully navigate collaborative learning designs.

Cooperative Learning and Social Interdependence Theory

Social interdependence theory suggests that when individual outcomes are tethered to the performance of other individuals and to that of a collective group it produces increases in overall productivity and generally higher achievement is observed (Johnson & Johnson, 2009). Positive

interdependence is said to exist when the success of the individual members of a group are dependent on the success of the group as a whole and the success of the group as a whole is dependent on the efforts of its individual members. Cooperative instructional designs incorporating positive interdependence have been shown to result in a number of desirable outcomes including increased motivation, an exchange of resources, and the development of mutual trust and responsibility among group members (Johnson & Johnson, 2009). Successful cooperative learning environments rely heavily on the existence of positive interdependence within their instructional designs.

Instructional designs incorporating the use of small groups that do not involve some feature requiring the simultaneous success of both the individual students and the collective group can foster several undesirable outcomes. When there is nothing in place to encourage student accountability for individual performance it is not uncommon for off-task behavior or excessive amounts of irrelevant socialization to occur during group work (Gillies & Boyle, 2010). Another common undesirable outcome of a lack of positive interdependence within groups is commonly referred to as social loafing or the "free rider" effect. This occurs when members of a group do not contribute an equitable amount of effort to meeting the group's objectives and instead rely on other group members to carry a greater load in order to compensate (Kohn, 1992; O'Donnell, 1994; Yamane, 1996). In general, successful cooperative learning occurs when individuals work together in small groups at a level of performance that is greater than that which could have been achieved by any of the group's individual members working alone (D.W. Johnson, 1992; D.W. Johnson & Johnson, 1999, 2009).

Collaborative Learning

The mission of collaborative learning is larger in scope than that of cooperative learning in that does not place emphasis on the completion of a single objective or assignment within a single educational or social context. Panitz (1997) explains that collaborative learning is:

> a personal philosophy, not just a classroom technique…it suggests a way of dealing with people which respects and highlights individual group members' abilities and contributions…CL practitioners apply this philosophy in the classroom, at committee meetings, with community groups, within their families and generally as a way of living with and dealing with other people. (p.4)

In the classroom, collaborative learning designs seek to encourage student development across several dimensions by shifting the locus of control from the teacher to the students and by engaging the students with open-ended tasks that do not have only one right answer. Specifically, students are largely expected to direct their own learning in collaborative classrooms by determining what it is that they should be learning, from what source, and how best to use the knowledge that they acquire, all while engaging in a constructive meaning-making that takes place in a social context.

It is important to note that simply working within a group does not constitute true collaborative learning. High-quality collaborative learning environments involve all members of the group being actively engaged in the mission of their group, each member of the team contributing towards the achievement of the group's collective objectives to an equitable degree, each student actively regulating their own learning as well as the learning of their fellow group members, and the maintenance of an atmosphere of shared respect. The degree to which the functioning of students working in small groups during collaborative learning designs varies

across these dimensions of performance ultimately determines the quality of overall collaboration within a group.

Specific Goals of PBL Defined

Flexible knowledge.

The concept of acquiring flexible knowledge refers to an individual's ability to develop a versatile understanding of a specific topic grounded within a deeper comprehension of peripheral and underlying principles within a particular discipline. When flexible knowledge is the desired outcome, instruction should not be designed specifically to foster student performance on any one particular outcome or assessment. Instead, learners that have acquired flexible knowledge in relation to a particular area of study are able to apply what they have learned in a number of academic and functional contexts. This is in direct opposition to the typical teacher-centered model of education where the design of instruction begins with a particular assessment and works backwards in order to ensure that students gain only that factual content knowledge that is specific to the form of examination being used.

Problem-solving/critical thinking skills.

The second goal of PBL is the nurturing of the skills required for becoming a competent problem solver. Being able to recognize salient aspects of a problem and determine and plan the learning actions that are required to obtain a solution are inherent in PBL learning formats. Being that the problem is the starting point in PBL, students are encouraged to develop problem-solving techniques such as metacognitive monitoring and various reasoning skills related specifically to critical thinking from the very beginning of instruction.

Self-directed learning.

The individual learning processes involved in SDL include the identification of what should be learned, how it should be learned, and the selection and critical evaluation of various sources of relevant information (Loyens, Magda, & Rikers, 2008). There is significant overlap between the component processes of SDL in PBL environments described by Hmelo-Silver (2004) and those that are thought to occur during successful self-regulated learning (SRL) (Loyens et al., 2008; Zimmerman, 1989, 2002, 2008; Zimmerman & Lebeau, 2000). The shared defining factor of both concepts is that learners are responsible for and have control of their own learning.

While similar, SDL and SRL are not identical. Self-directed learning can refer to both the design characteristics of the educational environment and to specific student characteristics, while self-regulated learning refers specifically to student characteristics. SDL can involve SRL, but SRL does not have to involve SDL. For example, the source of a particular instructional task is not a defining factor of SRL. Learners can still implement SRL in educational environments that are largely teacher-centered and assessment focused. In this way SRL can be considered a component of effective SDL in PBL.

Skills of collaboration.

Successful collaborative learning occurs when individuals work together in small groups at a level of performance that is greater than that which could have been achieved by any of the group's individual members working alone (Brufee, 1995). Skills related to successful collaboration include the ability to resolve conflicts in a constructive manner, getting to know and trust the capabilities of others in a group, accepting and supporting other group member's strengths and limitations, and promoting positive relationships through shared respect.

Additionally, the degree to which individuals in small collaborative groups co-regulate each other's learning has been identified as a potential contributor to successful collaborative groups (Rogat & Linnenbrink-Garcia, 2011; Järvelä & Järvenoja, 2011; Volet, et al., 2009).

Intrinsic motivation.

Several aspects of PBL are conducive to the development of student's intrinsic motivation to learn. The nature of problems typically used in PBL instructional designs tend to be meaningful in that they are applicable to real life situations in some way. Working with meaningful problems tends to be more engaging then other forms of passive learning. Additionally, a defining characteristic of SDL is that there is strong emphasis on the development of intrinsic motivation to learn. Students derive high levels of intrinsic motivation to learn when they have the opportunity to determine what and how they will learn.

Is PBL an Effective Form of Instruction?

Over the past two decades, the degree to which there exists empirical evidence that problem-based learning represents an effective form of instruction, often in comparison with traditional teacher-directed forms of learning, has been the focus of several research studies (Bahar-Ozvaris et al., 2006; Beachy, 2007; Capon & Kuhn, 2004; Hmelo, 1998; Schmidt et al., 1996; Kaufman & Mann, 1999; Krain, 2010; Loyens, Rikers, & Schmidt, 2006; McParland et al., 2004; Miller, 1997; Pease & Kuhn, 2011; Rideout et al., 2002; Schmidt et al., 2006; Wirkala & Kuhn, 2011; Yadav et al., 2011), review articles (Albanese, 2000; Berkson, 1993; Colliver, 2000; Hmelo-Silver, 2004; Kirschner et al., 2006; Maudsley, 1999; Norman & Schmidt, 1992; Sanson-Fisher & Lynagh, 2005), meta-analyses (Albanese & Mitchell, 1993; Dochy, Segers, van den Bossche, & Gijbels, 2003; Gijbels et al., 2005; Newman, 2003; Schmidt et al., 2009;

Vernon & Blake, 1993; Walker & Leary, 2009), and a meta-synthesis of the meta-analyses (Strobel & van Barneveld, 2009).

While problem-based learning has continued to grow in popularity among practitioners during this time (Schmidt et al., 2009), the findings of individual research studies and meta-analyses evaluating its effectiveness as an instructional practice have been largely inconsistent (Strobel & van Barneveld, 2009). These inconsistent findings may be due in part to the absence of a common, interdisciplinary definition for the term "problem-based learning" which has taken on a number of different, often contradictory, meanings as practitioners in various disciplines attempt to adapt the approach for their particular domain (Maudsley, 1999; Newman, 2005; Strobel & van Barneveld, 2009).

In addition to differences in how researchers have defined PBL in these studies, there were also significant variations related to the specific learning outcomes that were measured, the nature and design of the assessment strategies that were employed, and consequently, how "effective instruction" was ultimately defined. In addition to these variations across studies, several researchers (Albanese & Mitchell, 1993; Berkson, 1993; Vernon & Blake, 1993) have described the challenge of evaluating problem-based learning as an effective strategy in that "The outcome variables that are often the most highly valued, and best exemplify the special features of PBL, are often complex, multidimensional, and difficult to measure" (Vernon & Blake, 1993, p.560).

Research Reviews Related to the Effectiveness of PBL

The meta-analysis conducted by Albanese & Mitchell (1993) summarized the results of ten research studies that compared the outcomes of medical education programs that had adopted a PBL approach to other conventional medical education programs. The findings of the analysis

suggested that while PBL was often perceived as being more nurturing and enjoyable by students and faculty, and that PBL graduates perform as well or better on clinical examinations, the majority of the studies that were reviewed found that students taught using a problem-based learning approach did not perform as well on standardized tests of basic science knowledge in comparison to their counterparts taught using more conventional instructional methods. In light of these findings, the authors raise the concern that "standardized examinations have been criticized for providing only a measure of the examinee's ability to recognize the correct answer from a limited list of potentially correct answers…such measures do not assess the study approaches aimed at the deep learning that PBL promotes" (p.56).

Berkson (1993) provided a narrative literature review of ten studies examining the effectiveness of PBL in comparison to more traditional forms of instruction. While the findings of the review suggested that it was unlikely that the curriculum would have adverse effects on the development of students in programs using problem-based learning as the primary instructional technique, the author suggested that the resources required to teach using a PBL model were not worth the effort. Specifically, Berkson (1993) concluded that "The graduate of PBL is not distinguishable from his or her traditional counterpart. The experience of PBL can be stressful for student and faculty. And implementation of PBL may be unrealistically costly" (p.585).

The stated purpose of Vernon & Blake (1993) was to synthesize all available research evaluating PBL in comparison to more traditional methods of medical education from 1970 through 1992. In total, the meta-analysis involved 35 studies across 19 medical schools. The outcome of the analysis largely supported the findings of Albanese & Mitchell (1993) in that the authors reported that problem-based learning resulted in superior affect among faculty and

students, better student attendance, more self-directed learning, and a greater emphasis placed on deep understanding of content and less emphasis on memorizing. However, as in Albanese & Mitchell (1993), Vernon & Blake (1993) also reported that "traditional teaching methods were generally associated with higher scores on tests of basic science knowledge" (p.557).

In a review of the three aforementioned articles (Albanese & Mitchell, 1993; Berkson 1993; Vernon & Blake, 1993), in addition to eight subsequent individual research studies published between 1992 and 1998, Colliver (2000) concluded that there is "no convincing evidence for the effectiveness of PBL in fostering the acquisition of basic knowledge and clinical skills" (p.261). The author bases this conclusion on the argument that in all cases where researchers did report benefits related to the use of a PBL instructional format over more traditional designs, the effect sizes were not adequate enough to warrant doing so. Colliver (2000) further asserts that any variation in performance between students in the two different instructional arrangements can be "easily accounted for by pre-existing differences" (p.261) based upon evidence that the students who select PBL are generally better students. Additionally, Colliver (2000) suggests that the theory underlying PBL and its related research is:

> weak; its theoretical concepts are imprecise, lacking explicit descriptions of their interrelationships and of their relationships with observables, such as interventions and outcomes…the basic research is contrived and ad hoc, using manipulations that seem to ensure the expected results, regardless of the theory. (p.264)

While Colliver (2000) emphasizes the inadequacy of research findings in support of PBL in comparison to the benefits alleged by proponents of the method, the author does recognize that the literature suggests that problem-based learning is often perceived as "a more challenging, motivating, and enjoyable way to learn" (p.259).

Two companion articles published in response to Colliver (2000) (Albanese, 2000; Norman & Schmidt, 2000) challenge his statements related to the weakness of the theory and research supporting the use of problem-based learning. The authors of both articles contend that even if there are no significant differences in domain-specific outcomes between problem-based learning and traditional forms of instruction that the benefits of PBL related to providing a more challenging, motivating, and enjoyable learning environment for both faculty and students provides ample justification for its use. While the authors concede that "PBL does not result in dramatic differences in cognitive outcomes" and that "PBL *has* been oversold by its advocates, promising enormous benefits and largely ignoring the associated resource costs" (p.721), Norman & Schmidt (2000) argue that:

> the small effects and inconclusive findings derived from research on PBL result, not from the inadequacy of the theory and its basis in the laboratory, but from the futility of conducting research on interventions which, like PBL, are inadequately grounded in theory, in real environments, which are so complex and multifactorial, with so many unforeseen interacting forces, using outcomes so distant from the learning setting, that any predicted effects would inevitably be diffused by myriad unexplained variables…the fact that *any* significant effects have been observed is evidence of the effectiveness of PBL. (p.722)

The findings of Albanese (2000) concur with the observation made by Colliver (2000) that the theoretical basis for PBL provided solely by contextual learning theory is weak, and he provides four additional theoretical frameworks, information-processing theory, cooperative learning, self-determination theory, and control theory, which offer further explanation related to the effectiveness of problem-based learning. Additionally, Albanese (2000) suggests that

cooperative learning (CL) may function as the "active ingredient" in PBL environments. This supposition, summed by the statement "Perhaps one of the reasons for the ambiguous results from evaluations of PBL is the presence/absence of CL" (p. 734), was the impetus for the initial conceptualization of the current study.

The meta-analysis conducted by Dochy et al., (2003) that examined 43 studies, all conducted in a natural educational environment, was the first systematic review to consider research beyond the field of medical education in order to evaluate the evidence related to the effectiveness of PBL (Gijbels et al, 2005). Their results confirmed those of prior analyses (Albanese & Mitchell, 1993; Vernon & Blake, 1993) in that student performance related to the demonstration of their acquisition of domain-specific knowledge favored a more traditional instructional approach. However, findings also suggested that students educated using PBL demonstrated a superior aptitude for the application of knowledge and that this was largely dependent on the quality of the assessment methods that were used in a particular study relevant to their ability to account for these types of ability. Additionally, while the results of the review suggested that students acquired less knowledge during PBL in comparison to traditional instructional formats, it also suggested that students in PBL retained more of what they have learned for extended periods of time.

In a systematic review and meta-analysis Newman (2003) evaluated 91 articles cited by previous reviews in an effort to identify sources of high quality evidence for the effectiveness of PBL. To this end, a set of inclusion criteria were developed and applied in order to rule out those studies that should be excluded from the meta-analysis. These criteria required that all included studies must have involved participants in post-secondary education programs, must have utilized a randomized controlled trial, controlled clinical trial, a controlled before and after

study, or an interrupted time series experimental design, and that the studies must have involved the objective measurement of student performance. Of the 91 studies that were identified only 12 met the inclusion criteria utilized by the research team. Despite the limited pool of high quality research relevant to the effectiveness of PBL as defined by the study's set of inclusion criteria, the findings of Newman (2003) were consistent with those of previous reviews. Specifically, the author reported that student performance on knowledge related outcomes tended to favor traditional environments, while students and instructors preferred PBL.

In a detailed review of the fundamental characteristics of problem-based learning and the existing evidence related to its effectiveness, Hmelo-Silver (2004) concludes that "PBL offers the potential to help students become reflective and flexible thinkers who can use knowledge to take action" (p. 261). In response to the discrepant findings of several meta-analyses examining the outcomes related to knowledge resulting from PBL in comparison to knowledge obtained as a result of traditional methods, Hmelo-Silver (2004) states that "Although multiple choice tests measure knowledge, they may not get at the type of extensive and flexible knowledge aligned with the goals of PBL" (p.249). While Hmelo-Silver (2004) provides several examples of strong evidence for the use of PBL, the author recognizes that empirical support remains limited by a lack of research involving strong experimental control and a gap in the literature related to the contributions of motivation and collaboration to the outcomes that result from PBL.

The meta-analysis conducted by Gijbels et al. (2005) involved an examination of outcomes reported from 40 research studies that focused on the effectiveness of PBL in the context of the types of assessments that were used by the individual studies as a means of assessing the compatibility of their findings with the fundamental goals of problem-based learning. This study sought to address the concerns raised by previous reviews (Albanese &

Mitchell, 1993; Hmelo-Silver, 2004) that the detection of all positive outcomes that are characteristic of PBL environments via traditional methods of assessment is unlikely. It also aimed to investigate the supposition that "a valid assessment system would evaluate students' problem-solving competencies in an assessment environment that is congruent with the PBL environment" (Gijbels et al., 2005, p.32).

Gijbels et al. (2005) conducted their analysis by investigating the influence of assessment format as the primary independent variable in the study. For the purpose of analysis, the assessment format used in each study was categorized via the use of a "theory-based model of the cognitive components of problem-solving" (p.33) derived from Sugrue (1995). Using this model, the authors coded each assessment format based upon which of the three levels of the knowledge structure was measured. Assignment to the level 1 category corresponded with assessment formats that measured a students' mastery of *concepts* as evidenced by their ability to select or recognize examples with correct attributes and explain why the examples are correct representations. Level 2 assessment formats measured student performance related to the construct of *principles* by their ability to identify similar problems and select, generate, and/or explain predictions or solutions. Assessment formats categorized as being at level 3 of the knowledge structure focused on the degree to which participants demonstrated aptitude within the construct of application conditions and procedures defined as the ability to select, perform, and explain correct task-specific procedures.

Gijbels et al. (2005) found that the "effect of PBL differs according to the levels of the knowledge structure being measured" and that "PBL had the most positive effects when the focal constructs being assessed were at the level of understanding the principles that link concepts" (p.45), which was categorized as level two in the analysis. No negative findings were identified

linking the outcomes of PBL to assessments categorized as measuring performance at the third level of the knowledge structure in the analysis. The researchers also reported that students performed at least as well as students in traditional formats on assessments coded at level 1. From these findings, in reference to the effects of PBL on student performance, Gijbels et al. (2005) concluded, "students' path toward expertise has been accelerated" (p.45). Additionally, the authors stated, "it is clear that the method of assessment has an important influence on the reported effects of PBL" (p.47).

In a brief review of the existing literature concerning PBL, Sanson-Fisher and Lynagh (2005) provide commentary related to the possible reasons for the vast and rapid expansion of problem-based learning throughout the medical education field and beyond, despite the statement that "empirical data do not strongly support claims that PBL leads to advantageous educational outcomes" (p.259). The authors suggest that the wide adoption of PBL in medical education is due in part to a change in how the community at large views the medical profession as being more accepting of a democratic approach to patient care. In this modern model of medicine described by Sanson-Fisher and Lynagh (2005), the patient is more willing and able to voice complaints, get multiple professional opinions, and make direct demands of their medical providers. In this way, the authors suggest that problem-based learning prepares medical students for this type of professional climate in that "PBL is seen as more democratic and humanistic: the individual's voice is valued and students are no longer silent receptors of knowledge from their superiors" (p.259).

Sanson-Fisher and Lynagh (2005) argue that the wide adoption of problem-based learning is also due to strong evidence that students enjoy, and are more enthusiastic about, learning in a PBL environment in comparison to traditional educational formats. Furthermore,

the authors suggest that in addition to PBL actually being more enjoyable for students, it also *appears* more enjoyable in comparison to traditional learning formats that expect students to assume a very passive role. Its desirable appearance, in addition to its having a "high face validity" (p.260) in that it appears to approximate the types of processes a medical (or any other) professional may have to engage in, has contributed significantly to the willingness of educators and practitioners to accept PBL (Sanson-Fisher & Lynagh, 2005).

In a review of the literature related to several "pedagogically equivalent" (p.75) instructional approaches that they refer to frequently as "minimally guided", Kirschner et al. (2006) argue that instructional designs utilizing a high degree of instructor guidance and worked examples are superior to those that are more inquiry-based and student centered. They suggest that there is a strong base of evidence against the use of constructivist-informed instructional methods dating from the mid-1950's that has either been largely ignored or circumvented by proponents of "minimally guided" instruction by occasionally representing equivalent pedagogical techniques under new names when the currently popular "minimally guided" approach is discredited. The authors state that several instructional approaches were created this way in that "this pattern produced discovery learning, which gave way to experiential learning, which gave way to problem-based and inquiry learning, which now gives way to constructivist instructional techniques" (p.79). The genealogy of problem-based learning presented by Kirschner et al. (2006) does not align with several other accounts of PBL's initial conception and development (Barrows & Tamblyn, 1980; Schmidt, 1993; Schmidt et al., 2009; Williams, 1992).

The primary argument proposed by Kirschner et al. (2006) is that these "minimally guided" approaches ignore the constructs of human cognitive architecture and are "likely to be ineffective" (p.76). Specifically, the authors suggest that these instructional approaches are

incompatible with both information-processing theory and cognitive load theory in that the techniques require the allotment of substantial cognitive resources on behalf of the learner in order to process and acquire new knowledge. In contrast, the authors state that instructional approaches that provide structure through the presentation of worked examples serve to lighten the cognitive load needed to process, acquire, and retain new knowledge and are consequently superior to the group of strategies, including PBL, which they refer to as "minimally guided".

The commentary related to problem-based learning provided by Kirschner et al. (2006) evoked a response on behalf of proponents of PBL instructional methods in the form of three companion articles (Hmelo-Silver et al., 2007; Kuhn, 2007; Schmidt et al., 2007) published in a single issue of the same journal a year following the original article. The issue also included a reply to the response articles on behalf of proponents of CLT (Sweller et al., 2007). In general, proponents of PBL disagree with the conclusions offered by Kirschner et al. (2006) in that they argue that PBL does not constitute minimally guided instruction (Hmelo-Silver et al., 2007; Schmidt et al., 2007), that PBL *is* compatible with cognitive theories of learning including CLT (Schmidt et al., 2007), that the supposition that PBL does not work at all or is inferior to more structured approaches is not well supported in the existing literature (Hmelo-Silver et al., 2007), and that the "one or the other/right or wrong" tone of the stance taken by Kirschner et al. (2006) does not account for the complexity of learning environments or the outcomes that they aim to encourage (Hmelo-Silver et al., 2007; Kuhn, 2007).

Schmidt et al. (2007) attribute the "incorrect" (p.95) classification of PBL as unguided or minimally guided made by Kirschner et al. (2006) to their confusing the ultimate goal of student independence with there being no guidance or minimal guidance during problem-based learning. They argue that PBL is not minimally guided in that students receive various levels of support

both prior to, and during PBL instruction in the forms of training in group collaboration skills and tutor facilitation provided through a variety of methods. Additionally, Schmidt et al. suggest that assigning complex tasks to groups allows for a decrease in the cognitive load that is required to address the task via the dispersal of the load across group members. This is accomplished via PBL by activating the prior knowledge of individual group members and encouraging them to contribute their expertise towards the collective outcomes of the group via collaborative discussion.

Like Schmidt et al. (2007), Hmelo-Silver et al. (2007) disagree with the claim made by Kirschner et al. (2006) that PBL should be categorized as a "minimally guided" instructional approach. They argue that problem-based learning can involve a high degree of structure and guidance via multiple channels depending on the nature of the instructional climate. Further, the authors suggest that the instructional practices advocated for by Kirschner et al. are nearly indistinguishable from many of the techniques used to scaffold student learning and ultimately decrease cognitive load in PBL environments. The authors challenge the narrow scope of the literature provided as evidence for the failure of PBL by Kirschner et al. and they describe several empirical studies that support the use of problem-based learning as an effective mode of instruction. Hmelo-Silver et al. conclude that addressing the question of how we should teach is a complex endeavor that involves the consideration of many factors including specific educational contexts and the life-long outcomes that we would aspire to for learners in any environment.

In building upon the conclusion of Hmelo-Silver et al. (2007), Kuhn (2007) argues that the concerns of Kirschner et al. "…are misplaced and that the most pressing concern facing educators and challenge to educational reformers is not in fact how to teach students but rather

what to teach them" (p.110). She proposes that in the context of our current culture, which is rapidly evolving, that the task of predicting what students will need to know for success later in life is an impossible one. She argues that this provides ample justification to focus instruction on equipping students with the *skills* of inquiry rather than just spoon-feeding them the outcomes. In this light, Kuhn contends that it is not appropriate to identify which teaching method is "right or wrong" as Kirschner et al. (2006) appears to propose. In contrast, she suggests, "…there is a place for both direct instruction and student-directed inquiry" that there is a "need to contemplate instructional methods within the broader context of instructional goals" (p.112).

In their reply to the three companion response articles in the same issue, Sweller et al. (2007) uphold that:

> There is no theoretical reason to suppose or empirical evidence to support the notion that constructivist teaching procedures based on the manner in which humans acquire biologically primary information will be effective in acquiring the biologically secondary information required by the citizens of an intellectually advanced society. (p.121)

Much of this conclusion seems to be due to a continued misinterpretation of the fundamental characteristics of problem-based learning as they are reviewed in the current research. Specifically, the suggestion made by Sweller et al. (2007) that the emphasis on skills of self-directed learning in PBL equates with a de-emphasis on instructional guidance is not supported by any of the sources referenced in the current review.

In response to the proposition that collaborative discussion within small groups serves to decrease cognitive load during PBL made by Schmidt et al. (2007), Sweller et al. state that "Cooperation or collaboration…imposes costs in terms of cognitive load in that the coordination and execution of communication and interaction in groups is, in itself, often a cognitively taxing

experience" (p.117). Despite the clear description of the tactics used in PBL prior to instruction in order to provide students with training to support their ability to demonstrate skills of collaboration provided by Schmidt et al. (2007), Sweller et al. suggest "While we may want students to learn to cooperate and collaborate, why not teach those skills separately in a guided fashion" (p.117). This fundamental disagreement between proponents of PBL and those that advocate for the use of worked examples related to the contribution of collaboration during problem-based learning contributed to the framework for the primary investigation in the current study.

In reference to the thorough description of scaffolding techniques that are common to PBL provided by Hmelo-Silver et al. (2007), Sweller et al. suggest that "the only scaffolds they seem to ignore are providing learners with a problem and a problem-solving procedure that can be used for generating this solution" (p.117). This too, seems to be the result of a misinterpretation of the fundamental characteristics of PBL. The suggestion to provide a single problem-solving procedure negates the attributes of a problem well suited for PBL instruction in that it would not likely be "…complex, ill-structured, and open-ended" (Hmelo-Silver, 2004, p. 244).

Sweller et al. (2007) question the existence of several of the skills that Hmelo-Silver et al. (2007) identify as being outcomes of PBL. In reference to the process of sense making during problem solving or to the acquisition of flexible learning skills they argue that the associated processes are "…rarely if ever described, let alone taught" (p.118). In response to the number of studies cited by Hmelo-Silver et al. in support of PBL as an effective teaching method, Sweller et al. state that "all seem fatally flawed" and are "…almost useless in determining effective instructional procedures" (p.118). The authors suggest that the only experimental design of any

worth is one where only one variable is altered at a time. This suggestion seems to ignore the commentary of many educational researchers (Albanese & Mitchell, 1993) related to the complexity of learning environments and the learners that inhabit them.

Sweller et al. state that the response made by Kuhn (2007) "presents a point of view with which we very strongly disagree" (p.119). Despite the non-confrontational, non-proselytizing tone of Kuhn (2007), Sweller et al. insist that her perspective is radical and appear to take great liberties in selectively highlighting small portions of her writing to confirm this. For example Sweller et al. (2007) states, "Kuhn (2007) believes we should deemphasize the teaching of scientific theories and findings in favor of learning the methods of science. She suggests we should consider, '…whether to teach knowledge at all' (p.110). Rather we should 'teach…the skills of knowledge acquisition' (p.110)" (p.119).

Strobel & Barnevald (2009) conducted a meta-synthesis of eight prior meta-analyses and systematic reviews (Albanese & Mitchell, 1993; Berkson, 1993; Colliver, 2000; Dochy et al., 2003; Gijbels et al., 2005; Kalaian, Mullan, & Kasim, 1999; Newman, 2003; Vernon & Blake, 1993) related to the effectiveness of problem-based learning in an attempt to identify variation in the studies to explain the discrepancy between their findings. They concluded that the inconsistency in the findings of previous reviews stemmed from whether researchers tended to focus on long-term retention of knowledge, which appears to favor PBL, or short-term retention, a goal that favored traditional forms of instruction. The authors confirmed the findings of several of the aforementioned studies that both students and instructors favored a PBL approach over traditional methods. Strobel & Barnevald (2009) concluded, "PBL is significantly more effective than traditional instruction to train competent and skilled practitioners and to promote long-term retention of knowledge" (p.55).

Walker and Leary (2009) conducted a meta-analysis of 82 studies in a further attempt to account for the continued disagreement of findings from research aimed at assessing the effectiveness of problem-based learning. The authors expanded upon the model provided by Gijbels et al. (2005) in that they sought to develop categories to code the individual studies in order to detect any variation that may be due to differences in the design of the instructional environment, the academic or professional discipline, the problem type, or the format of assessment. The codes for instructional type were largely based upon the taxonomy of PBL as described by Barrows (1986) and included the codes lecture-based cases, case-based lecture, case method, modified case-based, problem-based, and closed-loop problem-based. Problem type codes were developed from the eleven problem types provided by Jonassen (2000). These included logical, algorithmic, story, rule using, decision making, trouble-shooting, diagnosis-solution, strategic performance, case analysis, and dilemma. The authors utilized the three levels of assessment types as originally included in Gijbels et al. (2005), which included the codes concept, principle, and application.

The researchers found that outcomes varied significantly across disciplines. Studies within teacher education reported the most favorable outcomes related to PBL while studies within the disciplines of engineering and science reported the least favorable outcomes related to PBL. The results of the analysis in relation to assessment level departed from the findings of Gijbels et al. (2005) in that they identified the largest effects on application assessments (level 3) and found statistically significant positive effects in favor of PBL in relation to all three assessment types. Analyses related to problem type and PBL method were relatively inconclusive given the large representation of medical education diagnosis-solution problems and lack of detail in many studies related to the specific design of instruction. In light of their

findings, Walker and Leary (2009) concluded "Across all of the analyses run, PBL students either did as well as or better than their lecture-based counterparts" (p.24).

In an effort to control for the many variations of PBL models across institutions and disciplines that may contribute to the discrepancies in findings of previous analyses (Gijbels et al., 2005; Walker & Leary,2009), Schmidt et al. (2009) conducted a meta-analysis of 270 curricular comparisons involving PBL instruction at a single medical school in the Netherlands. They compared several dimensions of performance outcomes of the students and the PBL program as a whole to those of seven other "conventional" medical schools in the Netherlands that do not utilize a PBL model. The authors state that in addition to controlling for variations in instructional design or implementation across institutions that utilize PBL, the design of the analysis was especially strong in terms of experimental validity in that all Dutch medical students are admitted to medical schools via a centralized "weighted lottery" based upon their achievement on a national entrance examination. This process inadvertently results in a balanced population of students in terms of their age, gender, socioeconomic status, and motivation across institutions. This serves to level the variance that can exist between individual students that could ultimately influence institutional performance outcomes.

Schmidt et al. (2009) found that the average student enrolled in the PBL curriculum demonstrated interpersonal skills that were superior to 92% of the students enrolled in a more conventional curriculum. In light of these results the authors concluded that "…collaborating in small tutorial groups indeed facilitates the acquisition of such skills" (p.237). Additionally, the average PBL student outperformed 79% of their conventional counterparts on measures of practical medical skills. On measures related to institutional performance, the PBL program outperformed the conventional institutions in every dimension examined in the analysis.

Average PBL student ratings related to their perceptions of the quality of their instructional program surpassed 75% of those provided by conventional students, the average student in the PBL program graduated faster than 70% of conventional student, and the PBL program retained approximately 12% more students on average over a ten year period.

Much smaller differences in favor of the PBL program were reported in relation to the students' acquisition of medical knowledge and diagnostic reasoning. Specifically, the authors found that PBL students fared 3% better than the average conventional student in their acquisition of medical knowledge and 5% better than the average conventional student in the area of diagnostic reasoning. In response to the critiques made by Kirschner et al. (2006) related to the ineffectiveness of PBL as an instructional method, Schmidt et al. (2009) conclude that the findings of their analysis "…do not support their hypothesis" (p. 238). They state that "There is no indication in our findings that students in a problem-based curriculum learn less content knowledge" and that "PBL seems to promote, more than conventional education does, the development of professional skills…in ways preferred by students…in a more effective and efficient way" (p.238).

Origins of the Current Study

The primary aims of the current research have been shaped by several studies that have preceded it. These studies have raised questions related to whether cooperative learning is the "active ingredient" in PBL (Albanese, 2000), whether PBL encourages students to become effective collaborators (Hmelo-Silver, 2004), if collaboration during PBL represents an impediment to learning (Sweller et al., 2007), or if collaboration is a necessary component of PBL at all (Bahar-Ozvaris et al., 2006; Pease & Kuhn, 2010; Wirkala & Kuhn, 2011). The experimental design of the proposed research has also been inspired by several prior studies that

have employed a within-subjects arrangement in order to examine the outcomes of PBL instruction compared to instructional techniques using a more traditional lecture/discussion format (Capon & Kuhn, 2004; Pease & Kuhn, 2010; Wirkala & Kuhn, 2011; Yadav et al., 2011).

The study by Bahar-Ozvaris et al. (2006) sought to assess the hypothesis that cooperative learning is the "active ingredient" in PBL instruction put forth by Albanese (2000). They compared the performance of students in a traditional lecture/discussion instructional format to those in PBL with a cooperative component. The authors accomplished this via the implementation of a between-subjects parallel-groups research design in which they used statistical analysis to assess the significance of variance between the control groups (traditional lecture/discussion) and experimental groups (PBL). They found that the students in the PBL condition gained significantly more domain-specific knowledge as measured by an individual assessment and that achievement was greatest in groups that reported the highest quality of cooperation.

The study by Capon and Kuhn (2004) was conducted within two sections of a graduate-level business course in an executive MBA program. The purpose of the study was to compare outcomes related to student performance on written assessments following each of two separate instructional strategies. The instructional strategies of interest were a traditional lecture/discussion (LD) method and problem-based learning. The researchers identified two topics that were typically addressed in the course that were independent of one another and amenable to both PBL and LD instructional formats. They systematically varied the form of instruction that was delivered so that the instruction received by participants in each section was crossed with those in the other. In other terms, the study by Capon and Kuhn (2004) represented a crossed 2 X 2 design as depicted in Table 1.

Table 1

Overview of the research design utilized by Capon and Kuhn (2004)

Group	Topic 1	Topic 2
Class 1	PBL	LD
Class 2	LD	PBL

Table 1 is only an approximation of the systematic manipulations of the instructional design by Capon and Kuhn (2004) in that the researchers in the study do not provide detail as to the order in which the sections received the various treatments.

There is little known about the quality of the group interactions during the PBL conditions as Capon and Kuhn (2004) state that "these groups were not facilitated or monitored…no specific data are available regarding what occurred during this group activity" (p.66). The chi-square test (X^2) was used to evaluate the differences between student performance following the two instructional methods. There is no discussion of why this method of hypothesis testing was utilized and there is little discussion of the magnitude of the results. The authors found that participants demonstrated greater amounts of understanding or integration of new information into their pervious conceptions as a result of PBL when compared to the outcomes related to the LD method of instruction. The study by Capon and Kuhn (2004) makes an important contribution to the literature supporting the use of PBL, despite its limitations, in that it established a method of conducting research on the effects of problem-based learning in a natural environment while maintaining strict experimental control.

The research conducted by Pease and Kuhn (2010) involved two separate, related studies which took place over two years with undergraduate physics students at a university in Lima, Peru. The first study sought to replicate the findings of Capon and Kuhn (2004) by examining the differences in student performance in two different treatment conditions through the use of a crossed 2 X 2 within-subjects design. The researchers compared the performance of students in

two separate sections of a physics class taught by the same instructor. The independent variable in this study was the manipulation of two levels of instructional format (Problem-based learning or Lecture/Discussion).

The researchers identified two fundamental, distinct concepts "of equivalent complexity" (Pease & Kuhn, 2010, p.61) that were typically taught in the course in order to use as a vehicle to systematically manipulate the two instructional formats in a consistent manner across the two sections. Both sections spent seven hours devoted to instruction related to the first concept, electromagnetic field, during the first and second weeks of the course. Section 1 received instruction related to this concept via the lecture/discussion method and section 2 received instruction related to the concept via PBL. The instructional strategies were then crossed in the third and fourth weeks during the presentation of content related to the second concept gravitational field so that section 1 received instruction in this topic via PBL and section 2 was taught using the LD method. Table 2 provides an illustration of the experimental design used in study 1.

Table 2

Overview of the research design utilized in study 1 by Pease and Kuhn (2010)

Group	Topic 1	Topic 2
Section 1	LD	PBL
Section 2	PBL	LD

The researchers measured students' learning of the concepts by assessing their comprehension and application of the course content. Their comprehension of domain-specific knowledge was assessed via three written examinations following weeks 2, 4, and 12. These examinations consisted of open-ended questions in the format of a case. The researchers assessed students' ability to apply what they had learned via the administration of two examinations during weeks 9 and 16. The application examinations consisted of two open-ended questions

requiring students to explain a scenario, which required the use of the content taught in the course in previous weeks.

The study by Pease and Kuhn (2010) utilized X^2 as a means of determining whether their findings were statistically significant. The chi-square test is used when the research question only requires a binomial (two possible outcomes) explanation. A detailed discussion as to why the researchers chose to use chi-square as a means of hypothesis testing in lieu of other more sensitive statistical tests is absent from the article. Pease and Kuhn (2010) reported that "Examination of individual patterns shows that in both classes, the majority of the students performed better on the concept learned via PBL than on the concept learned via lecture" (p.71).

Building upon the findings of the first study that PBL was superior to LD in relation to student performance on assessments of comprehension and application, the second study reported in Pease and Kuhn (2010) sought to identify the specific components of PBL that resulted in the aforementioned desired results. Specifically, the second study sought to examine the role of two of the social components of the PBL treatment used in the first study. The two social components that were identified consisted of the distribution of cognitive load among group members and the collaboration among students to solve the actual problem that is presented. The researchers assessed the contribution of each of these factors in the second study by implementing a second 2 X 2 crossed within-subjects experimental design where the independent variable was the level of collaboration present during the instruction. The second study took place one year after the first and occurred within the same course with the same instructor and covered the same content. The manipulation of the treatment conditions and timeline associated with the assessments were also identical to those utilized in study 1. Table 3 provides an illustration of study 2.

Table 3

Overview of the research design utilized in study 2 by Pease and Kuhn (2010)

Group	Topic 1	Topic 2
Section 3	PBL-Individual	PBL-Teams
Section 4	PBL-Teams	PBL-Individual

The researchers reported that there was not a significant difference between the performance of participants as a result of the manipulation of the two instructional designs of interest suggesting that the social component of PBL may not be necessary for its success. The authors offered further support for this statement by reporting that a comparison of student performance during the PBL-teams condition during study 2 (shared workload absent) was not significantly different from that of the PBL condition in study 1 (shared workload present). As in study 1 the chi-square statistic was utilized as a means of theory testing.

While the study by Pease and Kuhn (2010) is important in that it further demonstrates a viable method for conducting PBL research in a natural educational environment while maintaining strict experimental control, it is not without flaws. The primary purpose of both studies reported in this article was to examine the effects of various forms of problem-based learning. However, the instructional designs utilized in the research conducted by Pease and Kuhn (2010) does not appear to involve PBL in its purest form. Pease and Kuhn (2010) states that "a primary defining feature of PBL is the contextualization of learning in a problem presented to students without any preparatory study in the subject matter" (p.58), this is problematic in that students in the study under review were each assigned reading which "introduced the concept, illustrating it with examples" (p.62), prior to participating in PBL instruction. Additionally, Pease and Kuhn (2010) states that the process of gathering and sharing information on behalf of the participants in the studies were "…structured by the instructor's selection of articles for students to read, as well as formulation of the problem to be addressed"

(p.63). This high degree of instructor influence and constraint may not be ideal for students' realization of the fundamental goals of PBL related to the development of skills related to SDL.

The researchers stated that the two topics targeted for instruction in the study were "of equivalent complexity" (Pease & Kuhn, 2010, p.61). However, the authors' do not provide any basis for this conclusion. Additionally, the research design does not account for any variability in student performance that may have been due to differences in instructional content.

The treatment conditions incorporating various forms of "PBL" in the studies by Pease and Kuhn (2010) do not adequately account for the implications of social interdependence theory in the design of learning environments where successful collaboration among group members is a goal. Furthermore, there is no attempt to examine the influence of the quality of collaboration in small groups on student performance. The design of the assessment methods used in the study, and the authors' conclusions resulting from an examination of student performance on the assessments, do not represent the perspective that the development of the requisite skills for collaboration is a worthwhile instructional outcome in its own right. A thorough evaluation of the implications of the findings that the social aspect of PBL may not be necessary for its success, as reported by Pease and Kuhn (2010), is challenging given that it may first be necessary to address the question: Can an instructional design without a collaborative aspect still be considered PBL?

The study by Wirkala and Kuhn (2011) builds upon prior research (Capon & Kuhn, 2004; Pease & Kuhn, 2010) in that it involved the examination of learning outcomes related to various forms of PBL in comparison to a more traditional lecture/discussion instructional design. The research by Wirkala and Kuhn (2011) is similar to the prior studies (Capon & Kuhn, 2004; Pease & Kuhn, 2010) in that it endeavored to examine the specific short-term outcomes related to

student learning following PBL in a natural classroom environment using a crossed within-subjects design. The study extends the previous research in that it incorporates a more elaborate experimental design that compares the outcomes related to three factors simultaneously where both Capon and Kuhn (2004) and Pease and Kuhn (2010) only compared two treatment factors at a time. Another distinction between previous research in this field and the study by Wirkala and Kuhn (2011) is that the research was conducted with sixth-grade students in a public school.

Similar to previous research, Wirkala and Kuhn (2011) stated that the two topics targeted for instruction in the study "were chosen to be equivalent in difficulty and equally unfamiliar to students" (p.1161). However, unlike the previous studies, the authors based their conclusions related to the equivalence of the two topics on the performance of participants on a written assessment of comprehension given prior to the students receiving any form of instruction related to the two topics. The researchers found that very few students were able to provide even a very basic definition for the topics on the comprehension assessment, an outcome which was interpreted to support the equivalency of the two topics (Wirkala & Kuhn, 2011, p. 1173).

Conceptually, the research design of Wirkala and Kuhn (2011) is a more efficient adaptation of the design used by Pease and Kuhn (2010) extended to a new educational context. Both studies sought to compare the outcomes resulting from PBL environments that included a collaborative component to those that did not involve collaboration. Additionally, both studies compared the outcomes that resulted from two PBL arrangements to those that resulted from traditional lecture/discussion. Pease and Kuhn (2010) accomplished these comparisons over a two-year period in two separate studies with four separate classes of students, whereas the study by Wirkala and Kuhn (2011) made their comparisons between the three factors of interest over approximately six months with three separate classes of students. The design of the study by

Wirkala and Kuhn (2011) represents a 2 X 3 Latin-square experimental design illustrated by Table 4.

Table 4
Overview of the research design utilized by Wirkala and Kuhn (2011)

Group	Topic 1	Topic 2
Class 1	PBL-Individual	PBL-Teams
Class 2	PBL-Team	LD
Class 3	LD	PBL-Individual

In addition to utilizing a more efficient design than previous studies, the data collection and statistical analysis utilized in the study was more refined. Wirkala and Kuhn (2011) is the first of the studies under review to make comparisons both within and between subjects through the use of multiple statistical tests including a t-test, the chi-square statistic, and the Wilcoxen rank-sum test. The authors found that student performance in response to both of the two forms of "PBL" (team & independent) was not significantly different. Additionally, the study by Wirkala and Kuhn (2011) confirmed the earlier findings of both Capon and Kuhn (2004), and Pease and Kuhn (2010) in demonstrating that learning outcomes related to the comprehension and application of content were superior following instruction utilizing PBL in comparison to a lecture/discussion method.

Although the study by Wirkala and Kuhn (2011) represents a clear evolution in experimental research in the field of problem-based learning, it also shares many of the flaws existing in prior studies in this field (Pease & Kuhn, 2010). While the strategy used by Wirkala and Kuhn (2011) to establish the equivalence of the topics targeted for instruction is an improvement from the methods used in Pease and Kuhn (2010), it is not without flaws. The assumption that the two topics targeted for instruction in Wirkala and Kuhn (2011) were equivalent in terms of their complexity was based on the outcome that participant performance on a comprehension assessment at baseline was similar across the two topics. However, the

participant performance was similar in that very few students were able to provide even a very basic definition for the topics. The logic that students' inability to respond on assessment targeting content for which they have no prior exposure can be interpreted as reliable evidence of topic equivalence is flawed, as this outcome may be achieved by asking students to explain any two topics of equivalent or varying difficulty that the students have had no prior exposure to.

Another concern is related to the absence of consideration regarding the essential components of successful PBL and collaboration within the research design of Wirkala and Kuhn (2011). Similar to Pease and Kuhn (2010) the study by Wirkala and Kuhn (2011) does not account for the implications of social interdependence theory in relation to instructional designs involving group collaboration. Specifically, there does not appear to be any aspect of the instructional design meant to encourage any degree of positive interdependence within the PBL-team conditions. This observation is supported by the authors' statements that "teams relied on one or two members to do most of the work, with the rest relaxing and saying little…teams showed varying levels of collaboration" (Wirkala & Kuhn, 2011, p.1164). Clearly, based on the authors' commentary, not all of the groups in the study actually engaged in a form of collaboration as it is commonly defined.

Neither study (Pease & Kuhn, 2010; Wirkala & Kuhn, 2011) appears to have provided students with training related to group collaboration skills prior to PBL instruction. It has been suggested that this type of training is important in that it can support the existence of high quality collaboration among group members in PBL (Schmidt et al., 2006). While the findings of Wirkala and Kuhn (2011) that suggest that collaboration may not be required for success in PBL is in agreement with those of Pease and Kuhn (2010), the authors still do not address the

fundamental question of whether instructional designs without collaboration can even be considered problem-based learning by definition.

Wirkala and Kuhn (2011) reported that students had "a total of 2 hours" (p.1160) over three class sessions to complete the PBL activity from start to finish. It is highly improbable that this represented a sufficient amount of time spent on each concept utilizing PBL instruction in its "best practice form" (p.1159). The researchers also reported that 20 of the 120 minutes allotted to each PBL condition was spent providing students with a condensed version of the lecture given in the LD condition. This appears to be in direct contrast with the authors'stated assumption that in PBL students should "engage the problem 'cold', without being introduced to relevant concepts" (p.1164). Additionally, the inclusion of a teacher-directed lecture during the "PBL" treatment conditions appears to be an irreconcilable confound in relation to the authors' ability to isolate the influence of the various levels of the independent variable "instructional design". Consequently, the authors' findings related to the effectiveness of one level of the independent variable in comparison to another must be interpreted with caution.

The 2 X 3 single Latin-square design utilized in the study by Wirkala and Kuhn (2011) lacked adequate balance to ensure that the researchers could properly account for any carryover or period effects that could have been present. It is not possible to achieve a balanced Latin-square in an experimental design examining three treatments without the use of multiple squares. Although it is sometimes necessary to use partially balanced crossover designs when participant resources are scarce, this should only be done in a way that does not overlook a treatment contrast of interest, or if it is assumed that there will be no carryover or period effects related to the research design.

While the aforementioned concerns raise several questions related to the reliability of the findings of Pease and Kuhn (2010) and Wirkala and Kuhn (2011) in relation to the contribution of collaboration to outcomes resulting from PBL, the studies offer clear examples of the utility of using a within-subjects crossed design to evaluate the efficacy of PBL in real educational environments. The current study adds to the literature in the area of problem-based learning by addressing the limitations of the prior studies by improving upon the quality of the conceptual framework, the instructional designs, the assessments, and the analyses that were utilized in the previous research.

CHAPTER III
METHOD

Participants

Participants were 47 undergraduate students at a large research-intensive public university. Participants consisted of a mix of pre-service teachers and education minors enrolled in three separate sections of an introductory course in educational psychology. The sections were taught by the same instructor over two academic semesters within the same calendar year. One of the sections was taught during the spring semester and two additional sections were taught concurrently the following academic year in the fall. The total number of students enrolled in each section varied from 17 in the spring section, to 24 in the first fall section and 27 in the second fall section. While 50 of 68 total students opted to participate in the study yielding a 74% rate of participation, the data for three of the participants had to be dropped from the study due to their absence from course meetings.

Course

The course within which the research was conducted is a required 3-credit class entitled "Educational Psychology: Principles of Classroom Learning". The course is intended to introduce students to many of the prominent theoretical perspectives related to the nature of learning and a number of the pedagogical practices common to practitioners within the field of education. It is typical for a dozen sections of the course, facilitated by several instructors, to be offered each semester. While the fundamental course content is consistent across sections, the instructional methods and materials that are utilized in each section of the course can vary based upon the preference of individual instructors.

The current study was conducted in three separate sections of the educational psychology course over two semesters. The instructional format for the course was listed as "mixed

methods" within the description provided at the time of registration and students received an email immediately following their enrollment providing a general overview of the various types of instruction that they would encounter in the section. This was done to afford students the option of taking an alternate section of the course that utilized a more traditional lecture/discussion format as the primary means of instruction.

Instructor.

The instructor for the sections of the course within which the current study occurred was also the primary investigator for the research. In an effort to minimize potential risk related to any bias or coercion that existed from this arrangement the instructor remained blind to the identities of the students in the course that had given consent to participate in the study until the final grades for the course were assigned. This was accomplished through the enlistment of a research assistant who collected the consent forms from students at the outset of the course and maintained them under lock and key until the completion of the semester.

Design

The design of the current study was inspired by previous research conducted within the field of PBL in the contexts of an undergraduate science course taught at a university in Peru (Pease & Kuhn, 2010) and a 6th grade class taught at an alternative middle school in New York City (Wirkala & Kuhn, 2011). As in the prior studies, the current study utilized a within-subjects design as a means of examining the effects of the independent variable "instructional format". Three levels of the independent variable (PBL-Positive Interdependence vs. PBL-High Positive Interdependence vs. PBL-Independent) were manipulated across three sections of an undergraduate educational psychology course in order to achieve a partially balanced Latin-

square design allowing for a thorough statistical analysis of any carryover that may exist from one experimental condition to the next.

Although it is typically considered by many researchers to be the gold standard in terms of experimental control, the use of between-subjects parallel-groups research designs in an applied field such as education can be problematic in terms of the limited opportunity that these designs afford in generalizing findings from a laboratory to more natural settings such as a classroom environment. In this context, crossover designs evaluated within-subjects represent a viable alternative to other more contrived models of experimentation. Beyond the obvious limitations of parallel group design related to external validity, it is often challenging to conduct randomized trials in educational environments without disrupting the typical student classroom experience and ultimately confounding instructional outcomes.

By eliminating the need to form contrived groupings and to isolate participants to a single treatment, the crossover design makes it possible to conduct strict experimental research within a classroom environment while ensuring a high level of external validity. This in addition to the fact that crossover designs typically require roughly half the number of participants to achieve the same strength as a parallel group trial (Elbourne et al., 2002), make them a viable option for researchers interested in examining the practice of collaborative learning. Two recently published experimental studies within the field of Problem-based learning (Pease & Kuhn, 2010; Wirkala & Kuhn, 2011), have utilized variations of the within-subjects crossover experimental design as a means of examining the role of collaboration in PBL instruction. These studies represent clear examples of the utility of these types of experimental designs for the study of collaborative learning in natural environments.

Research Questions

The current study involved an in-depth examination of the contributions of social context and collaboration within PBL instructional designs to student performance. The study sought to address the following guiding questions:

1) What is the influence of a high degree of positive interdependence within PBL groups on student performance compared to the performance of students engaged in group work during PBL that does not involve a high degree of positive interdependence?
    a. Is positive interdependence an essential component of the PBL method?
    b. To what degree does the quality of collaboration among group members effect individual and collective group performance?
    c. Is team assessment a viable method for encouraging high-quality collaboration within small groups in PBL?
2) What is the influence of the social aspect of group work on student performance in PBL compared to PBL instruction requiring individual problem solving without peer interaction?
    a. Is the social aspect of group work an essential component of the PBL method?
    b. To what degree does the social component of group work in PBL result in an increased cognitive load and a reduction in overall performance for individual students?
3) What is the influence of PBL instructional designs on the development of skills needed for successful collaboration?
    a. Is the examination of the contribution of collaboration in PBL to outcomes related to the acquisition domain-specific knowledge justified?

b. Should the development of the necessary skills for collaboration and the opportunity to obtain practice using these skills be viewed as a legitimate and important instructional outcome independent of other academic performance-based measures of successful learning?

Experimental Conditions

The current study involved the assignment of all participants to three experimental conditions within a natural instructional setting ensuring a high degree of external validity. The order of condition presentation was randomly assigned within the constraints of a partially balanced design. Table 5 outlines the various manipulations of instructional format within the design across the three sections of the course:

Table 5
Overview of the research design utilized in the current study

Group	Topic 1	Topic 2	Topic 3
Section 1	PBL-Positive Interdependence	PBL-High Positive Interdependence	PBL-Independent
Section 2	PBL-Independent	PBL-Positive Interdependence	PBL-High Positive Interdependence
Section 3	PBL-High Positive Interdependence	PBL-Independent	PBL-Positive Interdependence

Duration of Instruction

In accordance with the recommendations of Schmidt (2007), a 3-hour class session was dedicated to providing students with specific training related to the skills necessary for collaboration and PBL in general during the second week of the course prior to their being engaging in PBL instruction. This training involved an instructor-directed group discussion of scholarly articles related to PBL and collaborative learning and exposure to a practice problem, which the students were encouraged to solve in small groups. Students were given the majority of two consecutive 180-minute class meetings, one week apart, to engage in PBL for each of the three key concepts. The 5.5 hours spent on each instructional target during each of the three experimental conditions resulted in 16.5 total hours of PBL instruction across six class meetings

overall. The last thirty minutes of the course meetings during the fourth, sixth, and eighth weeks of the semester were dedicated to the administration of written comprehension assessments.

Targeted Instructional Content

Content related to three distinct theoretical perspectives, which are typically targeted for instruction in the course, were selected as the key topics in the current investigation. The specific instructional content that was targeted pertained to behavioral learning theory (BLT), cognitive theories of learning (CTL), and social-constructivist learning theory (SCLT). The content related to each of these three perspectives is considered introductory in that students do not need prerequisite instruction or knowledge related to any one of the three topics in order to understand any other. While the three key topics are independent of one another and can be taught in any order, they were presented in the same sequence across the three sections of the Educational Psychology course during the current study. This allowed the researcher to vary the order of the experimental conditions across the three key topics as a means of controlling for any difference in student performance that could be attributed to variations between the three topics.

Behavioral learning theory was always the first key topic targeted in the third and fourth weeks of the course, followed by cognitive theories of learning in the fifth and sixth weeks, and social-constructivist learning theory in the seventh and eighth weeks. General definitions for the three key topics that were targeted for instruction are provided in Table 6.

Table 6
Overview of the key topics targeted for instruction in the current study

Key Topic	Definition
Behavioral Learning Theory (BLT)	A perspective that suggests that learning occurs as a direct result of the influence of environmental stimuli on individual behavior.
Cognitive Theories of Learning (CTL)	A perspective that suggests that learning is the outcome of an individual's perception of environmental stimuli based largely upon their prior experience or preexisting conceptions.
Social-Constructivist Learning Theory (SCLT)	A perspective that suggests that learning results from the continual interactions that occur between individuals and their social world.

PBL Problems

The practice problem used in training during the second week of the course, in addition to the three problems that were used as the foundation for PBL instruction related to the three key topics, were designed to approximate real-world situations that educators in different contexts could potentially encounter. The case presented to introduce the practice problem during the second week of class described a scenario requiring students to assume the role of a parent planning a trip to a large metropolitan zoo for their 10-year old twin boys. The case specified that their plan should be based upon the premise that they want their children to have a rich educational experience at the zoo beyond the mere memorization of facts related to the animals that they would see. Instead, the students were encouraged to use concepts related to Bloom's Taxonomy in order to create an itinerary of activities that the children will participate in before, during, and after their trip to the zoo to ensure that they were engaged in higher-order learning.

The case used to introduce the problem related to the first key topic, behavioral learning theory, described a scenario requiring students to assume the role of a recent graduate from a university-based teacher preparation program responding to an advertisement for an employment opportunity at a private elementary school. The case, which consisted of a mock job advertisement from a newspaper and a letter from the school to prospective applicants, explains

that the “Burrhus Frederick School” is an institution where they “strongly believe that learning is best defined as the acquisition of various measurable and observable responses, skills, or abilities, academic or otherwise, as a direct result of environmental influence”. The letter directs prospective applicants to submit a 3-5 page plan of instruction outlining their educational philosophy in order to be considered for the open position.

The case corresponding to the second key topic, cognitive theories of learning, described a scenario requiring students to assume the role of a college student majoring in education that was interested in becoming an SAT tutor in order to earn extra income. The case was presented in the format of a job posting from an online social media site and an email from the mother of a high school student seeking to hire a tutor. In the email, Nancy Coding explains that her search for a tutor is not limited to finding someone who can just facilitate study sessions for her son Charlie, but that she is also interested in hiring someone that can develop a detailed study plan that she would be able to use to help Charlie when the tutor is not around. In her email, Nancy requests that the students create a draft of a detailed study plan for Charlie prior to meeting her for an interview.

The final case that students are given to initiate PBL instruction related to social-constructivist learning theory describes a scenario requiring students to assume the role of the coordinator of a summer camp that exists in their local neighborhood who is charged with developing a community outreach program for the campers to take part in. The case specified that the camp is run by the local municipality’s community center which has a strong commitment to ensuring that stakeholders of the community are socially aware and are highly educated related to the characteristics that contribute to being a good citizen. The case format consisted of a narrative outlining the mission of the community center and its underlying

principles and a memo sent from the director of the center outlining the requirements of the community outreach program that the coordinator must create.

Procedure

During the first course meeting students were provided with a physical copy of the course syllabus and a detailed description of the research study complete with consent forms. The primary instructor for the course answered any questions that students had related to the course syllabus, basic requirements, the research study, or any other topic related to the coursework. The primary instructor for the course, who was also the principal investigator in the current study, left the room while students completed the consent form for the study. The research assistant for the study remained in the classroom while students completed the consent form to address any additional questions that students had and to collect the consent forms when the students had finished. Once all consent forms had been collected, the research assistant maintained them under lock and key to ensure that the principal investigator for the study remained blind to the participant status of individual students. This was done in an effort to limit the risk of coercion that could exist from the principal investigator having dual roles as a researcher and the instructor of record for the coursework in the study.

The last 30 minutes of the first course meeting for each section was allotted for students to take a pre-test related to the three key topics that would be targeted for instruction during the PBL sessions. The pre-test consisted of three open-ended questions designed to assess students' prior knowledge of the three key topics and related concepts. Students' performance on the pre-test was used to encourage the formation of groups that were heterogeneous regarding the level of prior knowledge that group members had related to the three key topics whenever it was possible. It was only possible to utilize the pre-test results in organizing the student groups when

student performance on the assessment provided evidence of prior knowledge related to any of the three key topics. The majority of participants in the current study were unable to provide even a basic definition for any of the three key topics on the pretest. Ten of the fifty participants (20%) in the current study demonstrated a level of prior knowledge on the pretest that justified assigning them to different groups.

Students were assigned to teams of four by the research assistant for the study based on their status as a participant in the research and their performance on the pre-test if applicable. This was done in a way to ensure that the majority of groups were homogeneous related to the group members' participant status and heterogeneous related to their pre-test performance when possible. Beyond the use of participant status and pre-test performance, students were randomly assigned to their teams. The principal investigator remained blind to the identities of those students that gave consent to participate in the study throughout the research.

All students in the course received specific training related to the PBL process and collaborative learning prior to their participation in PBL instruction (Schmidt, 2007). Specifically, students were assigned to read two articles related to PBL (Savery, 2006; Newman, 2005), one article related to cooperative learning (Johnson & Johnson, 1992), reflect on all three articles in an online blog portal that was viewable by all students in the course, and comment on at least two of their classmates' blogs between the first and second class meeting. The first 45 minutes of the second class meeting was allotted for an instructor-guided lecture/discussion of the three articles and the blog entries. During this time the instructor provided a general lecture related to PBL and cooperative learning and then answered any specific questions that students raised related to either topic. During the next 45 minutes of the second course meeting the students read a brief article related to the characteristics that contribute to successful groups

during PBL instruction (Azer, 2004), and participated in a second instructor-guided lecture/discussion related to the examination of the components that result in successful outcomes during student-centered instructional designs.

Following a brief break, students were given their group assignments and were asked to relocate within the classroom so that they were seated with the other members of their team. Students were then informed that they would be working within their assigned teams during four of the next six class meetings that would follow and each student was given physical copies of the sample problem presented in case form in addition to the corresponding problem identification and information gathering worksheet. After approximately half of the work session had elapsed the students were given problem solution worksheets, which would typically be provided during the second and final work session of a PBL condition. Both the primary instructor and research assistant continuously monitored the groups during the practice session to provide scaffolding as needed and to address any questions or issues related to the PBL process. The last 15 minutes of the second class session was reserved for a brief recap of the practice PBL session. This consisted of a whole-class instructor-guided discussion of the PBL process and the types of strategies that students could utilize in future PBL sessions to increase their likelihood of success (Schmidt, 2007).

The first formal PBL condition began during the third week of the course. Each of the three PBL conditions consisted of two work sessions that were separated by one week. The first work session in a PBL condition was 3 hours in duration and the second was 2.5 hours in duration, for a total of 5.5 hours of PBL instruction allotted for each key topic in the course. The final 30 minutes of the second class meeting of a PBL condition was utilized for the administration of a comprehension assessment. The primary instructor and the research

assistant served as the facilitators/tutors during all PBL sessions. Every student in the course was provided with a physical copy of the problem presented in case form at the beginning of each PBL condition. Additionally, students were given a new set of worksheets at the outset of every work session, which served to provide scaffolding in the absence of the facilitators.

PBL Conditions

The three PBL conditions (PBL-Positive Interdependence, PBL-High Positive Interdependence, and PBL-Independent) were varied across sections of the educational psychology course to ensure that each PBL condition occurred during instruction related to each of the three key topics for the course (see table 5, p.47). This was done in an effort to isolate any treatment effects that could have been due to differences in the content related to each of the three key topics. Additionally, this design accounted for any carryover that could have occurred from one PBL condition to the next.

PBL-Positive Interdependence.

The PBL-Positive Interdependence condition (PBL-PI) involved students being asked to work in small groups to collectively address a problem presented in case format. Each small group was expected to submit a single problem solution, and each individual student was expected to take an evaluation of their comprehension of domain-specific content related to the formulation of the problem solution. While there was a degree of positive interdependence embedded in the instructional design through the requirement related to the submission of a collective problem solution for a shared grade, there was no other feature of the instructional arrangement in the PBL-PI condition that was meant to foster a high degree of positive interdependence among group members. Specifically, while students were instructed to work

together in order to devise a collective problem solution, there was no additional aspect of the instructional design that motivated individual students to contribute equitably in doing so.

PBL-High Positive Interdependence.

Like in the PBL-PI condition, students in the PBL-High Positive Interdependence condition (PBL-High PI) were required to work in small groups to solve a problem presented in case format. Additionally, just as in the PBL-PI condition, the PBL-High PI condition required that each small group submit a single, collective problem solution and that each student take an individual comprehension assessment related to domain-specific content relevant to the problem solution. In contrast to the PBL-PI condition, the PBL-High PI condition involved a comprehension assessment that utilized an evaluation strategy designed to encourage a high degree of positive interdependence among group members in the form of a "team assessment".

A team assessment provides educators with the opportunity to simultaneously maintain individual student accountability and encourage proactive collaboration among students within small group instruction. In a team assessment, each member of a collaborative group is given an assessment that they are to complete individually. Following the assessment, a shared score or grade is devised by averaging all of the individual performance scores from the members of a group. This arrangement ensures a balance between an individual group member's need for personal success and their obligation to ensure the success of all of the other members of their group.

PBL-Independent.

During the PBL-Independent condition (PBL-I) students were required to work individually to solve a problem presented in case format. While students did not interact with their classmates at all during the PBL-I condition, they were able to interact with either of the

PBL tutors upon their request. Each student was required to submit an individual problem solution and take an individual comprehension assessment related to the domain-specific content that was required to devise the problem solution.

Written Assessments of Learning

Student performance was assessed within the three broad categories of knowledge described by Gijbels et al. (2005). These three categories, or levels 1-3, correspond to students' mastery of concepts, principles, and their ability to apply knowledge. The primary focus of PBL is not on the development of static, domain-specific knowledge. Consequently, the primary emphasis in the current study was to assess student performance at levels 2 and 3 (Gijbels et al., 2005), as measured by their ability to demonstrate an understanding of the principles associated with the course content and in the application of those principles to address a novel situation or problem.

To this end, students were required to submit a formal problem solution and take a written comprehension examination immediately following the conclusion of each of the three PBL conditions during weeks 4, 6, and 8 of the course. In addition to the problem solution responses and the comprehension assessments, students were given a two-part final examination at the conclusion of the course. The first part of the final examination required that students submit a response to a novel problem presented in case form that necessitated the application of content related to each of the three key topics targeted for instruction during the 3 PBL conditions in week 14 of the course. The second part of the final required that students respond to multiple-choice items related to the key topics.

Problem solutions.

Students' ability to demonstrate their understanding of principles related to key topics and their ability to apply this knowledge in devising a solution to a novel problem was measured via the analysis of the artifacts of PBL instruction. Participants were required to submit a 3-5 page account of the solution that they composed during each of the three PBL conditions. All students were provided with a set of "problem solution worksheets" at the outset of the second work session for each PBL condition. While these worksheets provided a model structure for a written problem solution, the students were not required to follow any specific form or format in devising their written response to the problems. It was clearly communicated by the PBL tutors that the worksheets existed merely as a guide and students were advised that they could use whatever format that they deemed most appropriate to convey their solution to the problem.

Comprehension assessments.

In addition to an analysis of the artifacts of PBL instruction, participant performance related to level 2 knowledge (Gijbels et al., 2005), was evaluated through the administration of three written comprehension assessments, corresponding to each of the three key topics, which were designed to detect the depth of students' understanding related to course content. Comprehension examination questions were open-ended and required students to identify, define, and explain as many concepts related to the corresponding key topic as possible. The questions did not include any specific cues to concepts that were related to key topics. For example, the comprehension assessment corresponding to behavioral learning theory directed students to: Describe behavioral learning theory. Identify, define, and explain as many specific concepts related to this perspective as possible and discuss how they might influence the acquisition of knowledge. Students had 30 minutes to complete each comprehension assessment

at the end of the class meetings on the 4th, 6th, and 8th weeks of the course immediately following their submission of the written problem solution that was due for that day. Students did not have access to notes or any other outside source during the comprehension assessments.

Take-home final examination.

The "take-home" final examination consisted of the presentation of a novel problem in case form which was relevant to all three of the key topics targeted across the three PBL conditions.[1] The problem presented in case form was posted on the online portal for the educational psychology course following the class meeting during the 13th week of the semester. The case required that students assume the role of an educational consultant charged with advising a school board as to the way that their school district should approach instruction. It provided the perspectives of three separate groups of parents, with conflicting opinions as to how the school should teach their children. The three parent perspectives corresponded to the three key topics targeted for instruction via PBL during weeks 3 through 8 of the course. The case required that students compare and contrast the three parent perspectives and discuss the virtues and shortcomings of each as a means of guiding the board towards a decision.

The take-home examination required that students submit an individual response to the case outlining their proposed problem solution prior to the following course meeting which provided them with approximately one week to complete their response. This examination was used to assess students' performance in the context of knowledge levels 2 and 3, understanding of principles and application of knowledge to a novel situation, respectively (Gijbels et al., 2005). Students were allowed to use whatever resources that they deemed most appropriate to

[1] The case used to initiate the take-home final examination in the course was originally written for use in another section of the educational psychology course by Dr. Cindy Hmelo-Silver.

complete the exam and there were no specific requirements related to the form or format needed to complete the task.

In-class final examination.

The second part of the final examination was administered in the classroom during the fifteenth week of the course. This part of the exam aimed to assess student knowledge in the context of level 1, mastery of concepts (Gijbels et al., 2005). The exam was cumulative in that it consisted of fifty multiple-choice items covering all of the content related to the course. Twenty-seven of the fifty items on the examination corresponded to the three key topics targeted for instruction during the PBL conditions. Students were given 3 hours to complete the exam individually and did not have access to notes or any other outside sources.

Qualitative Measures of Performance

In addition to collecting data related to student performance via the physical artifacts resulting from PBL instruction and written assessments, data was collected to allow for an analysis of small group discussion during the experimental conditions involving group work. The data for this analysis was collected by strategically placing several digital audio/video recorders throughout the classroom. While a complete qualitative analysis of these data is outside the scope if the current study, the collection of these data will allow for student discourse to be transcribed and examined in an effort to further document the outcomes resulting from exposure to the various PBL formats. Additionally, these data will be utilized in an inductive analysis aiming to identify the behavioral, social, and performance indicators that correspond with various levels of quality related to collaboration. This will be crucial to the development of a clear definition of "high-quality" collaboration.

Research Survey

Students were given a written research survey during the 14th week of the educational psychology course. The survey was voluntary and student responses were kept anonymous. The survey was distributed immediately preceding the in-class final exam for the course. The primary instructor for the course left the room while students completed the survey. The survey included questions meant to gauge the students' preferences related to the various forms of instruction that they encountered throughout the course, whether they preferred to work in groups or individually, and whether they believed that there were benefits associated with their participation in PBL instruction beyond the acquisition of knowledge related to domain-specific content.

Analysis

The overall variance of student performance on the comprehension assessments, problem solutions, and final examinations were analyzed across conditions using several one-way repeated measures analyses of variance tests at the .05 alpha level of statistical significance. The one-factor repeated measures ANOVA was utilized to determine the degree to which the independent variables "instructional design", "section/sequence", and "period/topic" each contributed to variability in participant performance across the four primary sources of data in the current study. The between-subjects variables "section/sequence" referred to the section of the educational psychology course for which a subject was enrolled and the sequence of the presentation of the three levels of the independent variable "instructional design" to which the subject was exposed. The individual effects of these variables could not be isolated as the sequence of presentation of the independent variable was nested within the variable "section" (see table 5 p.51). The within-subjects variables "period/topic" referred to the three periods of

experimental conditions inherent in the research design of the current research and the three key topics targeted for instruction during the periods. The individual effects of these variables could not be isolated, as the sequence of the presentation of the key topics was not varied across the sections in the course (see table 5 p.51).

In addition to the omnibus test of statistical significance, the current study involved three additional *a priori* statistical contrasts. Three simple contrasts were conducted to evaluate any variance that existed between student performance during the PBL-PI condition as compared to the PBL-High PI condition, the PBL independent condition as compared to the PBL-PI condition, and the PBL-Independent condition as compared to the PBL-High PI condition.

CHAPTER IV
RESULTS

A research team of two independent scorers coded all of the data using a set of scoring rubrics for each data source in order to encourage a high degree of reliability related to the findings of the current study. The research team consisted of the principal investigator and another trained doctoral student who served as a research assistant for the study.

Coding Reliability

The two scorers were blind to the participants' identity, the experimental conditions associated with specific responses, and the scoring of the other member of the team during all coding. Cohen's Kappa with linear weighting (Cohen, 1968) was used to assess the extent of agreement between the two scorers' coding of participant performance. According to Viera & Garrett (2005), the Kappa statistic is:

> based on the difference between how much agreement is actually present ("observed" agreement) compared to how much agreement would be expected to be present by chance alone… Kappa is a measure of this difference, standardized to lie on a -1 to 1 scale, where 1 is perfect agreement, 0 is exactly what would be expected by chance, and negative values indicate agreement less than chance. (p. 361)

Table 7 provides a guide for the interpretation of the Kappa statistic at various values.

Table 7
Interpretation of Kappa

Kappa	Agreement
<0	Less than chance agreement
.01-.20	Slight agreement
.21-.40	Fair agreement
.41-.60	Moderate agreement
.61-.80	Substantial agreement
.81-.99	Almost perfect agreement

Note . Adapted from "Understanding interobserver agreement: The kappa statistic", by A. J. Viera & J. M. Garrett, 2005, *Family Medicine* , 37(5), 360-363.

An analysis of the agreement between the scorers' coding of participant performance on the comprehension assessments in the current study yielded a value for Cohen's Kappa = .73. An analysis of the agreement between the scorers' coding of participant performance on the problem solutions in the current study yielded a value for Cohen's Kappa = .83. An analysis of the agreement between the scorers' coding of participant performance on the take-home final examinations in the current study yielded a value for Cohen's Kappa = .84. Table 8 provides further detail related to the degree of agreement that was observed across data sources between the two scorers in the current study.

Table 8
Agreement between scorers across data sources

Data Source	Total # of Scores	Agreement Expected due to Chance	Frequency of Agreement	Weighted Kappa
Comprehension Assessments	571	119	324	0.73
Problem Solutions	666	145	352	0.83
Take-home Final	588	134	352	0.84

Statistical Analysis

The primary research questions in the current study were addressed via four separate analyses of the variance (ANOVA) that existed between participant performance on written assessments and problem solutions and three additional planned simple contrasts examining the significance of variance between the three levels of the independent variable "instructional design" for each source of data in the study. Additionally, analyses were conducted to examine

the influence of the nuisance variables "section/sequence" and "position/topic". The variable "section" referred to the section of course for which a participant was enrolled, "sequence" referred to the sequence in which the three experimental conditions were presented, "position" referred to the order of presentation of a particular condition, and "topic" referred to the key topic that was targeted during each condition. All analyses were conducted using one-way repeated measures ANOVA at the .05 alpha level of statistical significance.

Coding for Comprehension Assessments

A hierarchical coding system was employed to evaluate the complexity of participant responses on the comprehension assessments that corresponded to each of the three key topics in the course. The coding system involved scoring participant responses related to the four primary concepts for each of the three key course topics using an ordinal scale of six levels of complexity. For each primary concept a student identified in their response, a score was assigned in order to denote the complexity of the students' explanation based on the scale outlined in Table 9.

Table 9
Coding system: Levels of complexity

Level	Characteristic	Description
0	No Mention	Fails to mention primary concept.
1	Identification	Identifies primary concept without providing an accurate definition.
2	Basic Definition	Provides only a vague or very basic definition.
3	Elaborated Definition	Provides basic definition and elaborates on definition.
4	Basic Explanation	Provides basic definition, elaborates on definition and provides basic explanation.
5	Elaborated Explanation	Provides basic definition, elaborates on definition, provides basic explanation and elaborates on explanation. An elaborated explanation includes evidence of a greater depth of understanding related to a single concept.
6	Application	Provides basic definition, elaborates on definition, provides basic explanation and elaborates on explanation. Evidence of application involves a description related to how information can be applied towards the implementation of a specific strategy in a practical context.

The coding levels were cumulative in that a response that was coded as meeting the criteria for a particular level of complexity must have satisfied the criteria for all of the levels of complexity lower than that particular level. Specifically, in order for a response to be scored as meeting the criteria for level seven, it must also have met the criterion for levels 1-6.

Tables 10-12 provide specific exemplars of student responses for each of the four primary concepts across the three key course topics at each of the six levels of complexity. These tables were provided to each of the members of the research team as a reference to be used as a means of encouraging greater consistency across scorers. The sample responses contained in the tables were selected from data collected during a separate pilot phase of the current study in an effort to avoid influencing the coding of the research team.

Table 10
Sample student responses and coding: Key topic 1

	Complexity of Response					
Primary Concepts	Level 1: Identification	Level 2: Basic definition	Level 3: Elaborated definition	Level 4: Basic explanation	Level 5: Elaborated explanation	Level 6: Application
Behavioral Learning Theory	Behavioral Learning theory is a theory based on how different methods can influence behavior and ultimately learning.	Behavioral learning theory emphasizes the relationship between the environment and behavior.	In behavioral learning theory, the environment directly influences an individual's behavior. Learning can be explained either by operant or classical conditioning.	Classical conditioning explains how an unconditioned stimulus can be paired with a neutral stimulus in order to lead to a conditioned response. Operant conditioning states that behavior is respondent to consequences.	In operant conditioning, learning occurs through the law of effect. Behaviors that are followed by good consequences increase and behaviors that are followed by bad consequences decrease through reinforcement, punishment, and shaping.	So the goal of a teacher who believes in behvaioralism is to create an environment that will encourage his students to learn as much as possible.
Reinforcement	Another theory that follows behavioral learning theory is one that uses reinforcement.	Reinforcement increases behavior.	There are two types of reinforcement, positive and negative reinforcement.	Reinforcement is a consequence that increases the likelihood that a particular behavior will occur more frequently in the future.	Positive reinforcement involves the addition of a stimulus that increases behavior. Negative reinforcement involves the removal of a stimulus that increases behavior.	An example of negative reinforcement is taking away homework for students that get an "A" on an exam.
Punishment	Punishment is another aspect of behavioralism.	Punishment decreases behavior.	There are two types of punishment, positive and negative punishment.	Punishment is a consequence that decreases the likelihood that a particular behavior will occur less frequently in the future.	Positive punishment involves the addition of a stimulus that decreases behavior. Negative punishment involves the removal of a stimulus that decreases behavior.	An example of negative punishment would be giving a student a "time out" from recess to decrease calling out.
Shaping	Shaping is often the repetitive response to a child's behavior.	Using reinforcement to gradually get a student to the right outcome.	Selectively reinforcing students in steps or stages to eventually reach a desired behavior.	When something is too hard for a student to do at first it can be broken down into smaller steps to help them learn how to do it through the use of reinforcment.	In shaping the student is expected to do more and more of the task in order to get reinforcement as time goes on.	A teacher could use a dotted line that they would gradually fade while providing reinforcement at each step in order to teach a child to write their name.

Table 11
Sample student responses and coding: Key topic 2

	Complexity of Response					
Primary Concepts	Level 1: Identification	Level 2: Basic definition	Level 3: Elaborated definition	Level 4: Basic explanation	Level 5: Elaborated explanation	Level 6: Application
Cognitive Theories of Learning	Cognitive learning theory is a theory of psychology that attempts to describe human behavior by understanding thought process.	Cogntiive learning theory emphasizes the relationship between the environment and individuals	It is the way that the individual perceives, interprets, and learns from the environment.	An Individual's prior knowledge and experience influence how they interpret stimuli from the environment.	Prior knowledge influences the way that environmental stimuli are processed in order to create internal representations of the stimuli in memory. This way learning can occur through aquiring new knowledge or by modifying existing knowledge based on experiences.	The cognitive theories of learning can help explain how students in a class can arrive at different conclusions even though they have been in the same lecture.
Information Processing Model	There are many specific models that fall under cognitive learning theory but one of the more well known is information processing model.	The information processing model depicts how we process information in our memory.	It depicts the various levels/stages of memory that new information goes through.	Information gathered from the environment passes through sensory memory and short term memory before being stored in LTM.	The various memory systems differ in depth and complexity. Sensory information enters the sensory memory and then into short term memory. Both of these are of limited capacity and are temporary storage. The information can only "survive" if active processing occurs and it makes its way into long term memory.	If what we are studying or trying to learn doesn't make it into our short term memory and then into our long term memory then it will be gone forever. The only way that information can be stored in LTM and retrieved for later use is through continuous encoding, maintenance, and rehearsal.
Memory	Memory is a big part of cognitve theories of learning.	Memory refers to the storage of information in the brain.	There are different types of memory storage and different types of memories stored in LTM.	The type of memory is based on an individual's experience. Declarative is memory of the "what", episodic is memory of an event or time period, semantic is memory of verbal speech, procedural is memory of "how".	Encoding is the way in which the mind organizes the information it receives. Sucessful encoding relies on organization, practice, and elaboration. Chunking, mnemonics, and elaborative rehearsal can facilitate this.	If a student is having trouble remembering vocab words than they can use the strategy of chunking to consolidate the like words to make them easier to remember.
Mnemonics	Mnemonics can help with remembering.	Strategies to aid in memory.	Can involve several strategies including acronyms, the keyword strategy, or the loci method.	Mnemonics involve giving meaning to things without meaning to help remember.	Acronyms involve coming up with a word where each letter stands for something that needs to be remembered.	Acronyms like "Roy-G-biv" can be used to remember information like the fundamental colors.

Table 12
Sample student responses and coding: Key topic 3

	Complexity of Response					
Primary Concepts	Level 1: Identification	Level 2: Basic definition	Level 3: Elaborated definition	Level 4: Basic explanation	Level 5: Elaborated explanation	Level 6: Application
Social-Constructivist Learning Theory	Social constructivist theories are when learning comes from the environment.	Emphasizes the relationship between the individual and social interaction.	The learning process is dialectical between an indivdiual and their social environment.	Describes how individuals construct knowledge through interactions with their social environment. It requires that the learner be an active participant in the learning process.	Learning can occur through an individual's interpretation of and participation in their social environment. Instruction based on this theory is often student-centered and involves authentic tasks.	The teacher should not be the primary source of knowledge in the classroom.
Collaboration/ Collaborative Learning	Collaborative learning is when students work in groups.	An instructional design that encourages students to learn from each other and contribute equally to the learning process.	When students work together to achieve an outcome that is greater than what they could have accomplished individually.	Every member of the group must contribute to the success of the group as a whole or every member of the group will fail.	Positive interdependence refers to an aspect of the instructional design that ensures that every student must succeed in order for the group to achieve success as a whole. This results in a state of collective efficacy where the group is able to accomplish more together than any one member of the group would have been able to accomplish alone.	PBL involves working in small groups to solve an ill-defined problem that does not have only one right answer.
Zone of Proximal Development	Another important theory is the zone of proximal development.	When a student is performing at the optimal level.	The zone of proximal development exists between what the student already knows and what they are not ready to learn.	A student is working in their zone of proximal development when they are given just enough support to complete a task at a level of difficulty that requires the student to work at their capacity but still be able to be successful.	If a task is too difficult the student may become frustrated and not be able to learn, if it is too easy they will still not learn. Students can "be in the zone" if the task is just hard enough but not too hard for them to complete.	In problem-based designs allow students to work together and help each other to stay in their zone of proximal development in accomplishing tasks that they would not be able to do alone.
Scaffolding	Another way to learn is through scaffolding.	Support given to a learner from a more experienced individual.	Giving just enough support so that they are able to complete the task.	This allows the learner to complete a task that they otherwise would not have been able to complete on their own.	Scaffolding involves the gradual reduction of support from the guide so that the learner can ultimately complete the task independently.	A teacher can provide a student with a topic sentence to start an essay.

Results of Comprehension Assessments

The overall analysis of variance of the comprehension assessment scores revealed that the effect of the independent variable “instructional design” was significant $F(2,92)= 13.63$, $p = .001$, and that the interaction between the variables “section/sequence” and “instructional design” was not significant $F(2,92)= .342$, $p = .71$. The means, standard error, and confidence intervals for the three levels of “instructional design” are provided in Table 13.

Table 13
Comprehension assessment scores

Instruction	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
PBL-PI	17.199	0.702	15.785	18.613
PBL-High PI	18.492	0.642	17.197	19.786
PBL-Independent	13.887	0.867	12.139	15.635

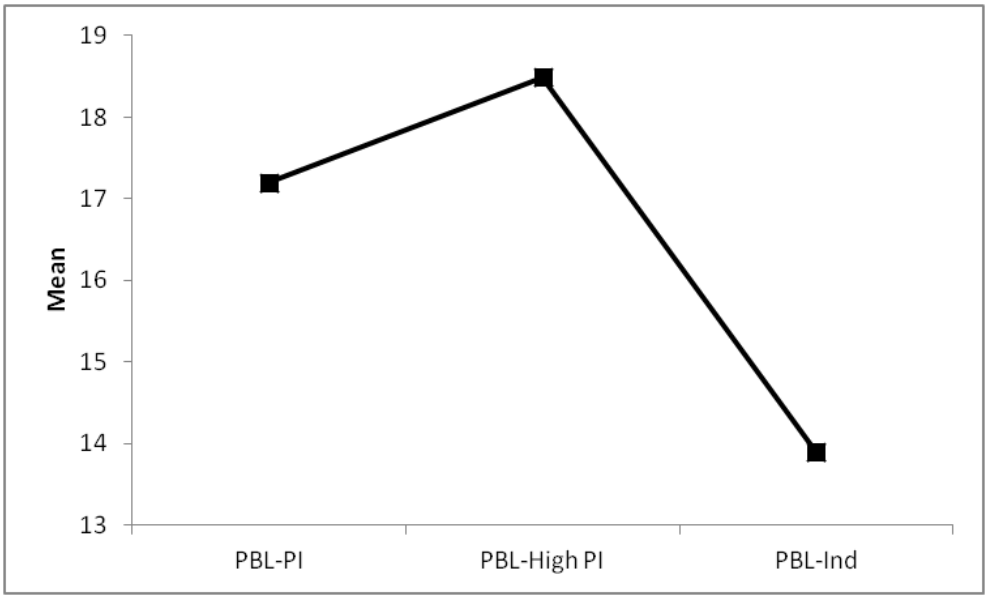

Figure 1. Means of comprehension assessment scores across the three levels of "instructional design".

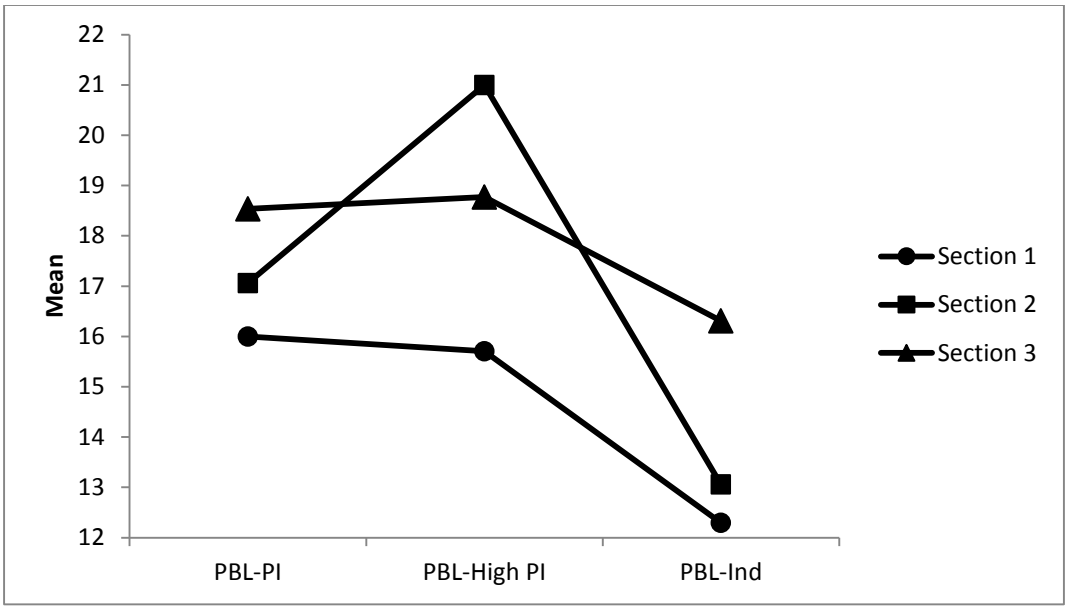

Figure 2. Means of comprehension assessment scores by section across the three levels of "instructional design".

In addition to a statistically significant main effect of the variable instructional design, the planned comparisons of the individual levels of the independent variable suggested that the outcomes of each of the experimental conditions varied to a statistically significant degree from all others. Specifically, the scores associated with subject performance during the PBL-PI condition varied from those obtained during the PBL-High PI condition to a statistically significant degree at the .05 alpha level ($p = .04$); and both conditions involving students working in groups varied from those obtained during the PBL-Independent condition to statistically significant degree at the .001 alpha level (PBL-PI vs. Independent, $p = .001$; PBL-High PI vs. Independent, $p < .001$). The outcomes of the *a priori* comparisons of the means of subject scores on the three comprehension assessments during each of the three experimental conditions are outlined in Table 14.

Table 14
Outcomes of a priori contrasts of comprehesion assessment scores

Instruction (I)	Instruction (J)	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval for Difference	
					Lower Bound	Upper Bound
PBL-PI	PBL-High PI	-1.293*	0.630	0.046	-2.563	-0.022
	PBL-Ind	3.312**	0.897	0.001	1.504	5.120
PBL-High PI	PBL-PI	1.293*	0.630	0.046	0.022	2.563
	PBL-Ind	4.605**	0.907	0.000	2.777	6.433
PBL-Independent	PBL-PI	-3.312**	0.897	0.001	-5.120	-1.504
	PBL-High PI	-4.605**	0.907	0.000	-6.433	-2.777

Note . *p < .05. **p < .01.

Following all planned comparisons, the data related to the comprehension assessment scores were arranged to allow for an examination of the influence of the variables "position/topic" on participant performance. An examination of the means of participant performance scores organized by period provided information related to any potential practice effects that may have occurred or the influence of the topic that was targeted during each period across the three sections. Practice effects consist of subject performance increasing over time as a result of repeated exposures to a specific form of treatment or instruction. This can be problematic in the interpretation of data as these effects may result in the false perception that a particular treatment provided in later periods of a within-subjects design is more effective than it actually is.

While the counterbalanced design of the current study renders the influence of the nuisance variables "position/topic" irrelevant in the interpretation of any treatment effects, this analysis was conducted in the interest of demonstrating the likelihood of these types of effects in order to assess the validity of previous research that did not benefit from a counterbalanced design. In the current study, it would be expected that the presence of significant practice effects would result in a gradual increase in subject performance following repeated exposure to PBL

instruction with performance being lowest during the first period and highest in the third period of instruction. The outcome of this examination is depicted by Table 15 and Figure 3.

Table 15

Means of comprehension assessment scores arranged by position/topic

Position/Topic	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1.Behavioral Learning Theory	17.036	0.583	15.878	18.194
2.Cognitive Theories of Learning	18.498	0.583	17.340	19.656
3.Social-Constructivist Learning Theory	13.700	0.583	12.542	14.858

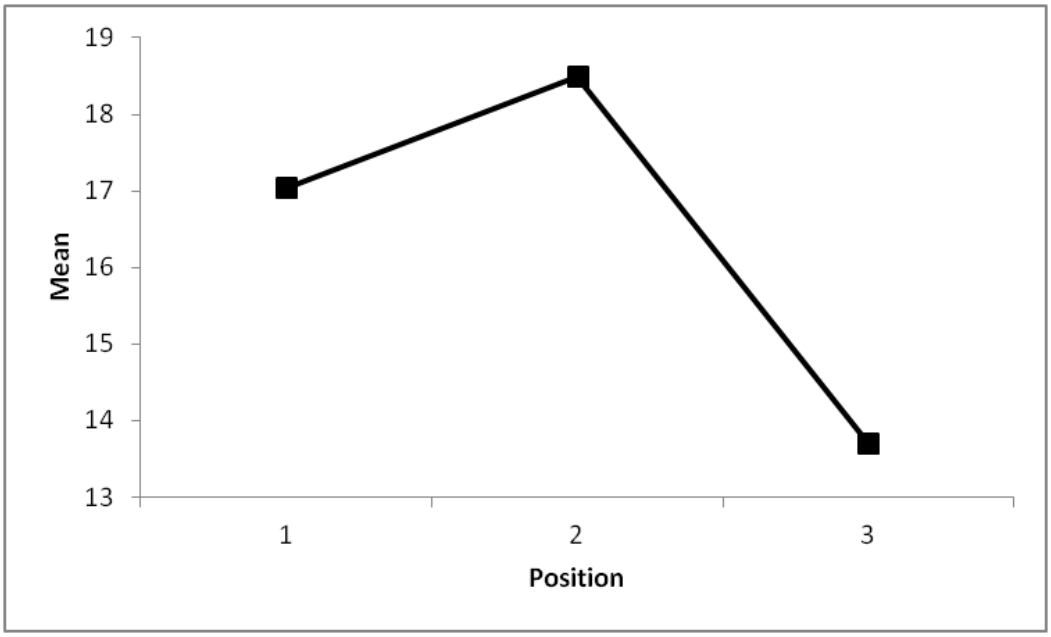

Figure 3. Means of comprehension assessment scores across the three levels of "position/topic".

These data suggest that subject scores were not influenced by practice effects to a significant degree. Instead, the low means of scores during the third period of instruction during the current study suggest a significant influence of the variable "topic".

Coding for Problem Solutions

A two-tiered hierarchical coding system was employed to evaluate the complexity and overall quality of the problem solution essays that subjects submitted in class immediately following each of the three periods of PBL instruction. The first tier of the coding system was

identical to that which was used to code the comprehension assessments (see Table 9, p.68). The first tier was designed to gauge the complexity of participant responses related to the four primary concepts for each of the three key course topics using an ordinal scale of six levels of complexity. Each primary concept that a student or group identified in their response was assigned a score in order to denote the complexity of the students' explanation based on the scale outlined in Table 9 (p.68).

The second tier used to score the problem solutions was designed to measure the overall quality of a response across the five dimensions: 1. Theme, 2. Application of Theory, 3.Response Addresses the Problem, 4. Practicality of the Proposed Solution, and 5. Clarity of the Writing. Scorers assigned a rating on a scale of 0-3 for each of these dimensions of quality. A description of each level corresponding to the dimensions of related to the overall quality of problems solutions is depicted in Table 16.

Table 16
Problem solution scoring tier 2.

	Overall Quality of Response			
Category	Level 0	Level 1	Level 2	Level 3
Theme of response	Response has no thesis.	Response does not have a clear thesis.	Response has a thesis but does not remain consistent throughout.	Response has a clear direction/topic/thesis supported by relevant literature.
Application of theory	Little or no use of psychological theory to justify response.	Appropriate/correct application of psychological theory is minimal.	Minor errors in the application of psychological theory to justify response.	Demonstrates appropriate use of psychological theory to justify response.
Response addresses the problem	The problem is not addressed by the proposed solution.	The stated problem is largely unaddressed by the proposed solution.	Some aspects of the problem are not addressed in full.	The response thoroughly addresses all aspects of the problem.
Practicality of the plan	There are no specific recommendations for a viable solution or the proposed solution is not practical or pedagogically sound.	There are major limitations regarding the utility of the proposed solution.	There are minor limitations regarding the utility of the proposed solution.	The proposed solution/instructional plan is logistically/pedagogically sound.
Clarity of the writing	Incomplete sentences, grammatical and spelling errors throughout the response. Writing is awkward and largely unclear.	Response has several grammatical errors, inconsistent sentence structure, spelling errors, or writing is unclear at times.	Response contains a few grammatical or spelling errors.	Response is clearly written with no grammatical or spelling errors.

Results of Problem Solutions

The overall analysis of variance of the problem solution scores revealed that the effect of the independent variable "instructional design" was significant $F(2,92)= 17.60$, $p < .001$, and that the interaction between the variables "section/sequence" and "instructional design" was also significant $F(2,92)= 3.68$, $p = .033$. The means, standard error, and confidence intervals for the three levels of "instructional design" are provided in Table 17.

Table 17
Problem solution scores

Instruction	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
PBL-PI	35.603	0.377	34.844	36.362
PBL-High PI	33.145	0.898	31.335	34.955
PBL-Independent	30.970	1.185	28.581	33.359

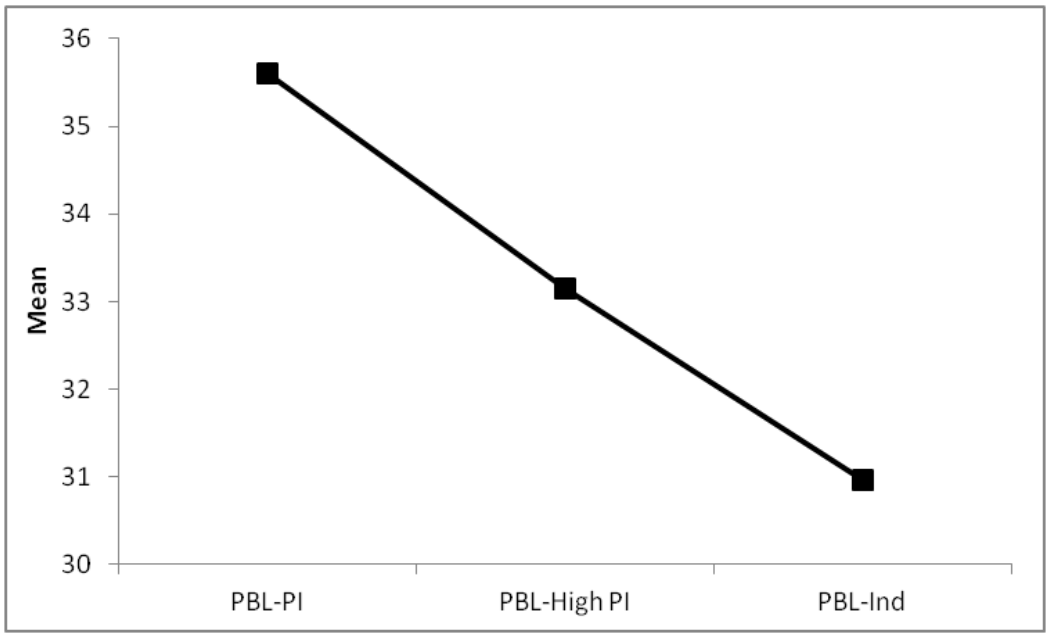

Figure 4. Means of problem solution scores across the three levels of "instructional design"

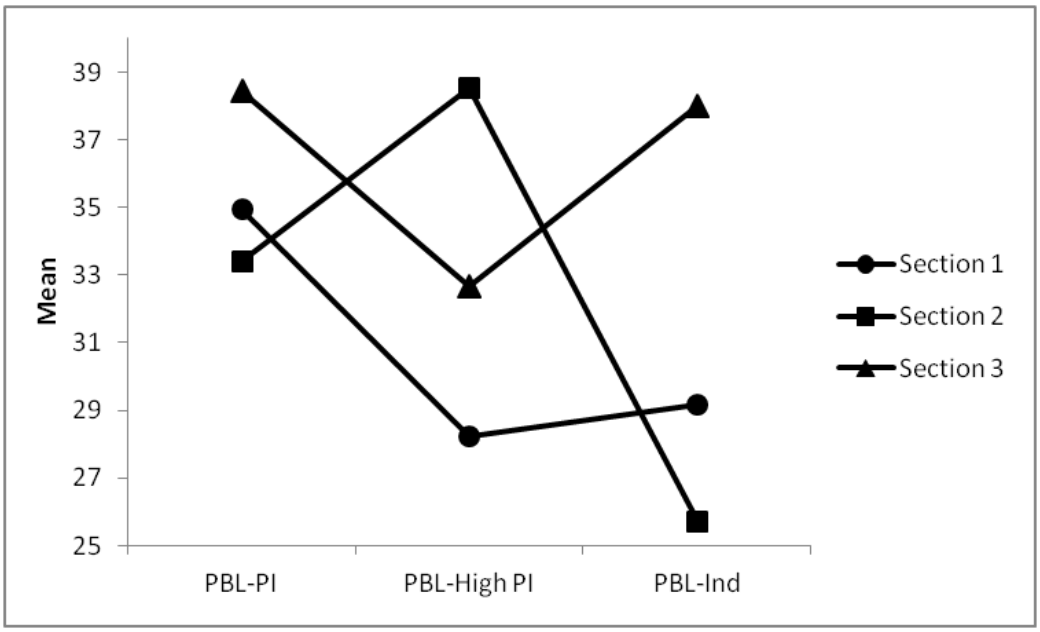

Figure 5. Means of problem solution scores by section across the three levels of "instructional design"

In addition to a statistically significant main effect of the variable instructional design, two of the three planned comparisons of the individual levels of the independent variable suggested statistically significant variance between scores. Specifically, the scores associated with participant performance during the PBL-PI condition varied in comparison to those obtained during both the PBL-High PI condition ($p = .01$), and the PBL-Independent condition ($p < .01$) to a statistically significant degree at the .05 alpha level. The outcomes of the *a priori* comparisons of the means of participant scores on the three problem solutions during each of the three experimental conditions are outlined in Table 18.

Table 18
Outcomes of a priori contrasts of problem solution scores

Instruction (I)	Instruction (J)	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval for Difference	
					Lower Bound	Upper Bound
PBL-PI	PBL-High PI	2.458*	0.957	0.014	0.529	4.386
	PBL-Ind	4.633**	1.104	0.000	2.408	6.858
PBL-High PI	PBL-PI	-2.458*	0.957	0.014	-4.386	-0.529
	PBL-Ind	2.175	1.673	0.200	-1.196	5.546
PBL-Independent	PBL-PI	-4.633**	1.104	0.000	-6.858	-2.408
	PBL-High PI	-2.175	1.673	0.200	-5.546	1.196

Note . *p < .05. **p < .01.

Following all planned comparisons, the data related to the problem solution scores were arranged to allow for an examination of the influence of the variables "position/topic" on subject performance. An examination of the means of participant performance scores organized by period provided information related to any potential practice effects that may have occurred or the influence of the topic that was targeted during each period across the three sections. The examination of these data suggested that repeated exposure to PBL instructional designs resulted in participants producing higher-quality problem solutions across experimental conditions. The outcome of this examination is depicted by Table 19 and Figure 6.

Table 19
Means of problem solution scores arranged by position/topic

Position/Topic	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1.Behavioral Learning Theory	31.277	1.148	28.967	33.587
2.Cognitive Theories of Learning	33.000	0.934	31.120	34.880
3.Social-Constructivist Learning Theory	35.128	1.084	32.945	37.310

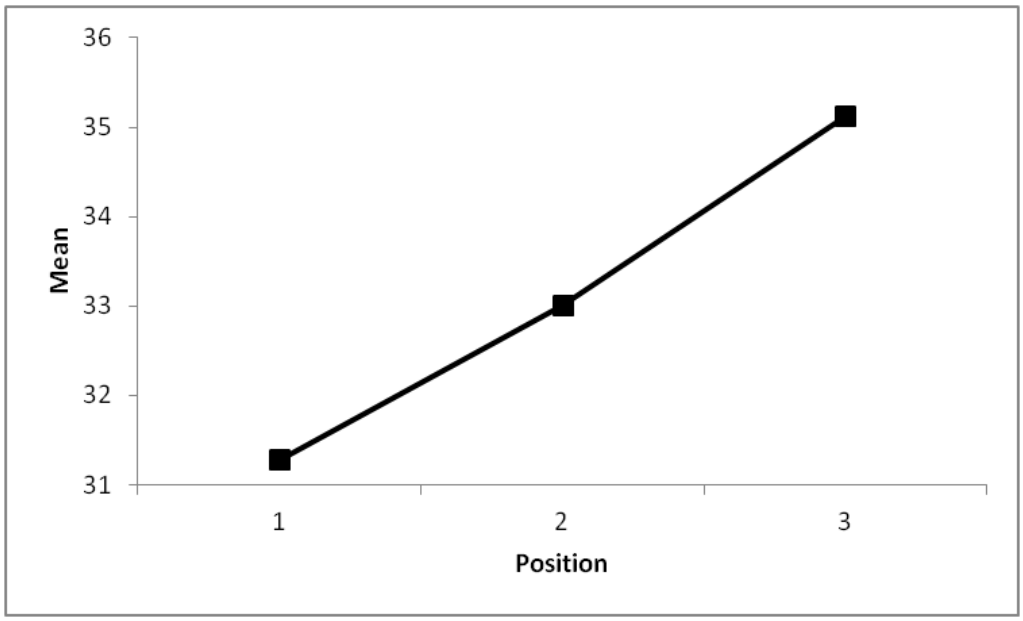

Figure 6. Means of problem solution scores across the three levels of "position/topic"

Scoring of In-class Final Examination

Twenty-seven of the fifty multiple-choice questions that comprised the in-class final examination for the course related to the three key topics targeted during the experimental conditions in the current study. After the final examinations were scored for accuracy, the scores corresponding to the twenty-seven questions related to the three key topics were isolated for further analysis. This consisted of grouping the questions by topic and devising a score for each group of questions based upon the percentage of accuracy of a subject's responses. Specifically, each participant yielded three separate scores that were based on their performance within each group of questions corresponding to each of the three key topics.

Results of In-class Final Examination

The overall analysis of variance of the in-class final examination scores revealed that the effect of the independent variable "instructional design" was not significant $F(2,92)= .017$, $p = .896$, and that the interaction between the variables "section/sequence" and "instructional design" was significant $F(2,92)= 11.785$, $p < .001$. The means, standard error, and confidence intervals

for the three levels of "instructional design" are provided in Table 20.

Table 20
In-class final examination scores.

Instruction	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
PBL-PI	72.787	2.682	67.383	78.191
PBL-High PI	74.158	2.661	68.796	79.520
PBL-Independent	72.451	2.340	67.734	77.168

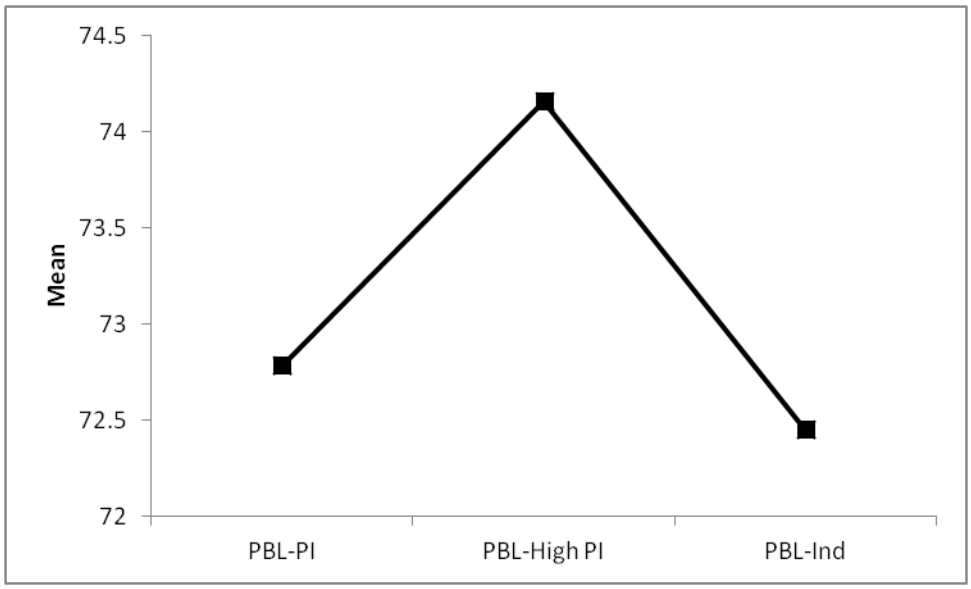

Figure 7. Means of in-class final examination scores across the three levels of "instructional design"

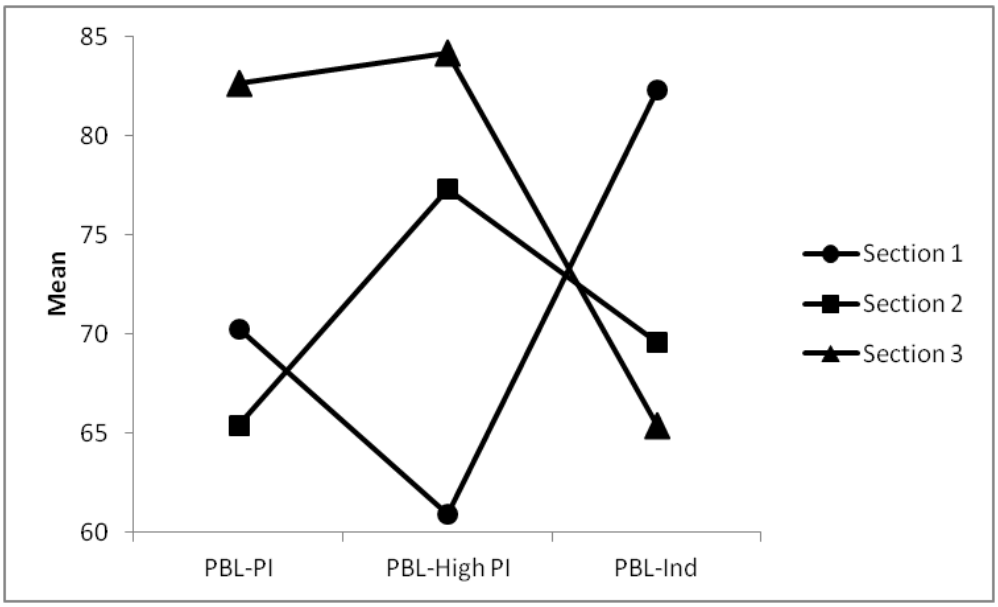

Figure 8. Means of in-class final examination scores by section across the three levels of "instructional design"

Following all planned comparisons, the data related to the in-class final examination scores were arranged to allow for an examination of the influence of the variables "position/topic" on subject performance. An examination of the means of subject performance scores organized by period provided information related to any influence of the topic that was targeted during each period across the three sections. The outcome of this examination is depicted by Table 21 and Figure 9.

Table 21

Means of in-class final examination scores arranged by position/topic

Position/Topic	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1.Behavioral Learning Theory	74.698	2.718	69.221	80.175
2.Cognitive Theories of Learning	63.914	2.732	58.408	69.419
3.Social-Constructivist Learning Theory	80.784	2.213	76.324	85.244

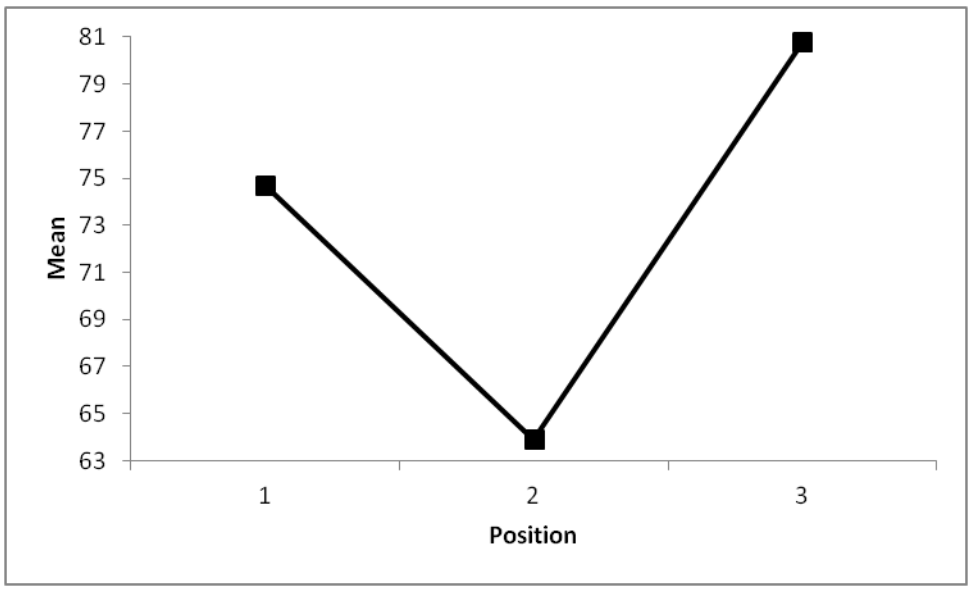

Figure 9. Means of in-class final examination scores across the three levels of "position/topic"

Coding for Take-home Final Examination

The coding system that was used to score the take-home final examinations was identical to that which was used to code the comprehension assessments and to the first tier of the coding system for the problem solutions (see Table 9, p.68). This system was used to gauge the complexity of subject responses related to the four primary concepts for each of the three key course topics using an ordinal scale of six levels of complexity. The final examination problem required subjects to apply what they had learned during each of the three PBL conditions. Consequently, each subject's take-home final examination yielded three separate scores corresponding to the complexity of their response related to the three key topics.

Results of Take-home Final Examination

The overall analysis of variance of the take-home final examination scores revealed that the effect of the independent variable "instructional design" was significant $F(2,92)= 13.16$, $p = .001$, and that the interaction between the variables "section/sequence" and "instructional design" was also significant $F(2,92)= 7.13$, $p = .002$. The means, standard error, and confidence intervals for the three levels of "instructional design" are provided in Table 22.

Table 22

Take-home final examination scores

Instruction	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
PBL-PI	15.877	0.753	14.368	17.407
PBL-High PI	14.696	0.981	12.718	16.674
PBL-Independent	13.129	0.768	11.580	14.678

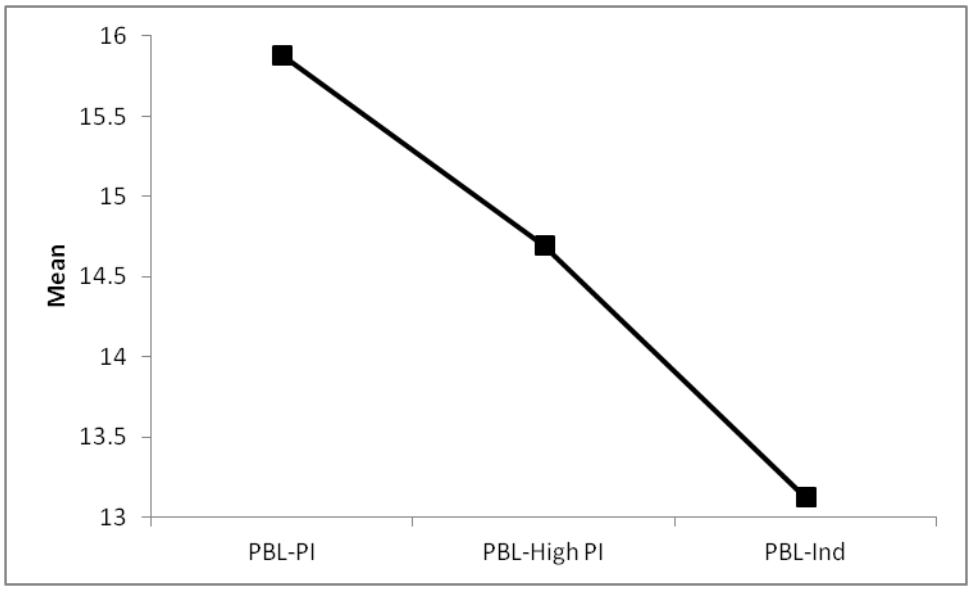

Figure 10. Means of take-home final examination scores across the three levels of "instructional design"

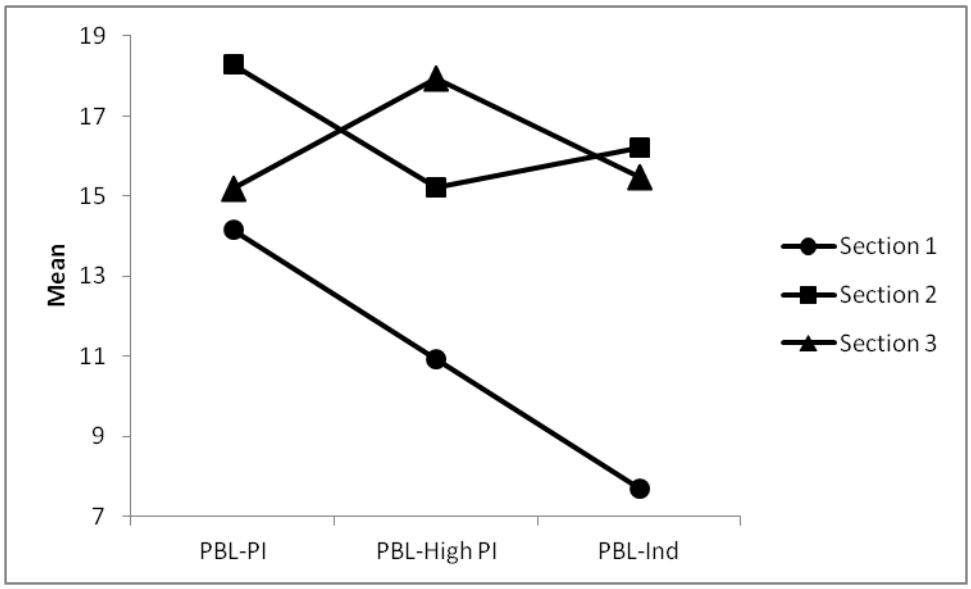

Figure 11. Means of take-home final examination scores by section across the three levels of "instructional design"

In addition to a statistically significant main effect of the variable instructional design, one of the three planned comparisons of the individual levels of the independent variable suggested statistically significant variance between scores. Specifically, the scores associated with participant performance during the PBL-PI condition varied in comparison to those obtained during the PBL-Independent condition ($p = .001$) to a statistically significant degree at the .001 alpha level. The outcomes of the *a priori* comparisons of the means of participant scores on the three problem solutions during each of the three experimental conditions are outlined in Table 23.

Table 23

Outcomes of a priori contrasts of take-home examination scores

Instruction (I)	Instruction (J)	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval for Difference	
					Lower Bound	Upper Bound
PBL-PI	PBL-High PI	1.919	0.833	0.160	0.488	2.871
	PBL-Ind	2.758**	0.760	0.001	1.225	4.292
PBL-High PI	PBL-PI	-1.919	0.833	0.160	-2.871	0.488
	PBL-Ind	1.567	0.958	0.109	-0.365	3.500
PBL-Independent	PBL-PI	-2.758**	0.760	0.001	-4.292	-1.225
	PBL-High PI	-1.567	0.958	0.109	-3.500	0.365

Note . *p < .05. **p < .01.

Following all planned comparisons, the data related to the take-home examination scores were arranged to allow for an examination of the influence of the variables "position/topic" on subject performance. An examination of the means of subject performance scores organized by period provided information related to any influence of the topic that was targeted during each period across the three sections. The outcome of this examination is depicted by Table 24 and Figure 12.

Table 24

Means of take-home examination scores arranged by position/topic

Position/Topic	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1.Behavioral Learning Theory	16.108	0.826	14.442	17.774
2.Cognitive Theories of Learning	14.898	0.853	13.177	16.619
3.Social-Constructivist Learning Theory	12.707	0.842	11.009	14.404

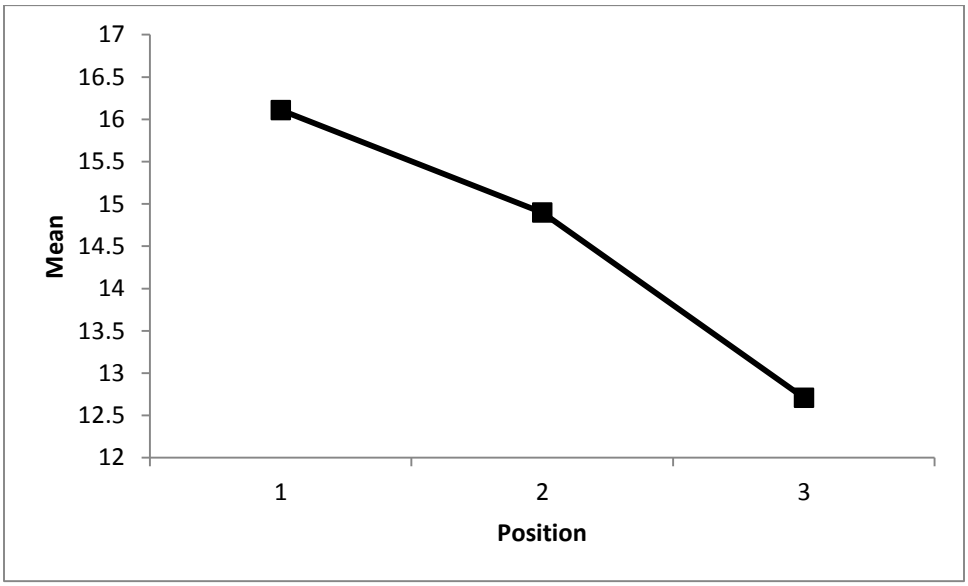

Figure 12. Means of take-home final examination scores across the three levels of "position/topic"

CHAPTER V
DISCUSSION

Purpose of the Current Study

The primary purpose of the current study was to extend the findings of previous research in the field of problem-based learning that have been interpreted as demonstrating that "collaboration is not one of the essential components of PBL" (Wirkala & Kuhn, 2011, p.1182). This objective has been accomplished through the current research by improving upon several of the flaws related to the theoretical framework, experimental design, and statistical analysis that were utilized in the implementation of the previous studies. In doing so, the current study also provides evidence that these design flaws may have contributed significantly to the outcomes reported by the researchers in the prior studies. In addition to addressing issues related to a lack of experimental control in the previous research, the current study improved upon the existing research in that it examined the effectiveness of PBL in its purest form in accordance with the defining characteristics provided by Hmelo-Silver (2004). Lastly, the current study contributes to the existing field of research on PBL by providing a model for understanding the mechanisms underlying the facilitation of successful collaborative learning environments through the application of social interdependence theory (Slavin, 1996) as a framework for the design of effective collaborative instruction.

Like previous studies (Capon & Kuhn, 2004; Pease & Kuhn, 2010; Wirkala & Kuhn, 2011), the current research sought to identify the components of PBL that contribute to its success by executing a research design with "strict experimental control" in a natural classroom environment. While it is crucial that educational researchers continue to strive to conduct rigorous experimentation as a means of empirically validating various instructional arrangements in order to identify the "best practice" pedagogies for various educational contexts, it is

important to note that classrooms are very complex environments that are not easily controlled. As a result, many researchers in the learning sciences have questioned the utility of attempting to control factors within the classroom for the purpose of experimentation, suggesting that this practice may not approximate "real" classroom environments (Norman & Schmidt, 2000). These researchers argue that creating a contrived and controlled environment in order to empirically validate instructional techniques undermines the fundamental purpose of conducting research to inform real classroom practice (Norman & Schmidt, 2000). Further, given the dynamic nature of teaching and learning in a classroom environment, it is unlikely that research conducted in a real classroom environment could ever be said to have "strict experimental control". While the design of the current study does not meet the commonly agreed upon definition for "strict experimental control", involving experimentation conducted in a controlled environment allowing for the manipulation of a single variable at a time, there were several factors that were carefully controlled including the instructor, the instructional content, instructional materials, and the time spent on instruction in order to ensure consistency across participants in the current study.

Additionally, the two tutors employed several strategies during the PBL conditions involving a social component to ensure that the conditions were facilitated consistently across the three sections of the course. These strategies included the tutors' use of a list of acceptable PBL facilitation techniques, a system for time allocation, planned observation, and regular meetings for debriefing. The list of acceptable PBL facilitation techniques that was used by the PBL tutors in the current study was adapted from Hmelo-Silver and Barrows (2006) and included the use of open-ended and metacognitive questioning, pushing for explanations, revoicing, summarizing, generating/evaluating hypothesis, mapping between clues and

hypotheses, checking that the written documents represent the group consensus, creating learning issues, and encouraging the construction of visual representations (p. 28).

The two tutors closely monitored the amount of time spent supporting each small group to ensure that they were equitable in the time spent with each team. Towards this end, the tutors systematically rotated from one group to another every ten minutes throughout the PBL sessions. The completion of planned observations involved each of the tutors monitoring the other while they provided support to a group at least once per PBL session. The tutors met for debriefing after every PBL session which involved the tutors sharing the results of their observations, providing feedback, and discussing their perceptions of the PBL process, individual group progress, and progress of the section as a whole compared to other sections. Further analysis of the audio/video data that was collected in the current research is required to provide additional evidence that the PBL tutors were unbiased in their delivery of support across groups and sections.

The study conducted by Wirkala and Kuhn (2011) employed a crossed 3X2 Latin-square design in order to assess the influence of the independent variable "instructional design" on subject performance (see Table 4, p.43). This limited the type of statistical analysis that could be conducted because the design did not allow every subject to be exposed to all levels of the independent variable, as is typical in repeated measures designs. Additionally, the researchers adopted the assumption that the two topics that they had targeted for instruction during the two periods of the study were "equivalent in difficulty" (Wirkala & Kuhn, 2011, p.1161) without conducting any form of statistical analysis following the collection of data in order to confirm this assumption. This arrangement made it impossible to account for any variance in

performance scores that was due to carryover (practice effects), position effects, or between-subjects error.

The current study addressed this limitation by employing a crossed 3X3 Latin-square experimental design which made it possible to account for any carryover, position effects, or between-subjects variability by exposing every subject to all three levels of the independent variable "instructional design". Specifically, the arrangement of the current study allowed for nuisance variables related to practice effects, carryover, and between-subjects variability to be counterbalanced as a means of negating the influence of these factors on the independent variable "instructional design". In addition to controlling for the influence of nuisance variables, the design of the current research allowed for an in-depth examination of the potential contribution of practice effects or differences between instructional topics in within-subjects designs that do not involve the counterbalancing of confounding variables. These examinations demonstrated that differences in the content of instruction had a clear impact on subject scores. This outcome raises questions related to the validity of the assumptions made in relation to the equivalence of topic difficulty in previous studies in the field of PBL (Pease & Kuhn, 2010; Wirkala & Kuhn, 2011).

Pease and Kuhn (2010) states that "a primary defining feature of PBL is the contextualization of learning in a problem presented to students without any preparatory study in the subject matter" (p.58). However, the researchers in the study assigned each participant reading which "introduced the concept, illustrating it with examples" (p.62), prior to participating in PBL instruction. Additionally, Pease and Kuhn (2010) states that the process of gathering and sharing information on behalf of the participants in the studies were "…structured by the instructor's selection of articles for students to read, as well as formulation of the problem

to be addressed" (p.63). While Wirkala and Kuhn (2011) states that students should "engage the problem 'cold', without being introduced to relevant concepts" (p.1164), the researchers in the study reported that 20 of the 120 minutes allotted to each PBL condition was spent providing students with a condensed version of the lecture that was given in the lecture/discussion (LD) condition. Wirkala and Kuhn (2011) states that "students learned about the relevant concepts via a condensed, 20-minute lecture…this lecture covered the concepts and theories pertinent to the topic" (p.1164-1165), and that "PBL students were provided the same essential information as LD students".

These aspects of the "PBL" environments in the previous studies do not account for several of the fundamental goals of PBL instruction. Specifically, students engaged in PBL "must have the responsibility for their own learning" (Savery, 2006, p.12). PBL environments should encourage the development of skills related to SDL by ensuring that "the tutor supports the process and expects learners to make their thinking clear, but the tutor does not provide information related to the problem—that is the responsibility of the learners" (Savery, 2006, p.16). The current study addressed the aforementioned limitations of the previous research by evaluating the outcomes of PBL in its purest form in ensuring that there were no aspects of the instructional design that involved preparatory exposure to the domain-specific content required to solve the problem. In addition, the primary investigator and research assistant served as guides and facilitators of the PBL process throughout the learning process and were never positioned to be the primary source of information in the classroom.

Successful collaborative learning environments involve all members of the group being actively engaged in the task at hand, each member of the team contributing towards the achievement of the group's collective objectives to an equitable degree, each student actively

regulating their own learning as well as the learning of their fellow group members, and the maintenance of an atmosphere of shared respect (Hmelo-Silver, 2004). The study by Wirkala and Kuhn (2011) did not involve an instructional design that was meant to encourage any of the aforementioned desirable conditions for successful collaboration during the PBL-team condition. Further, the authors' state that "teams relied on one or two members to do most of the work, with the rest relaxing and saying little…teams showed varying levels of collaboration" (Wirkala & Kuhn, 2011, p.1164).

Given that the instructional format utilized by Wirkala and Kuhn (2011) during the experimental condition meant to assess the contribution of the social component of PBL does not appear to meet the commonly accepted definition of a "collaborative" learning environment, the researchers' findings related to the lack of distinction between the outcomes resulting from the PBL-team condition as compared to the PBL-independent condition are not surprising, and must be interpreted with caution. Specifically, the authors' conclusion that "collaboration is not one of the essential components of PBL" (p.1182), does not appear to be supported by their findings. The existence of the aforementioned questions related to whether instruction provided in the study by Wirkala and Kuhn (2011) during the PBL-team condition constituted true "collaborative learning" or whether the instruction was not collaborative in nature and merely involved students being arranged in small groups to conduct work, supports the need for further experimentation in this area before final conclusions can be drawn related to the role of collaboration in PBL.

The current study addressed these limitations of the previous research by employing instructional designs incorporating varying degrees of positive interdependence among group members during the PBL conditions involving a social component. This was accomplished in

the PBL-PI condition by requiring each small group of students to work together to devise a written problem solution for a collective grade and take an individual comprehension assessment that required an understanding of the content required to solve the problem during PBL. While the instructional arrangement during the PBL-PI condition provided some degree of positive interdependence, the existence of interdependence was exclusive to the task of devising a single written problem solution that was representative of the collective consensus of the group for a shared grade. Alternatively, the PBL-High PI condition involved the existence of positive interdependence related to both the construction of a written problem solution that was representative of the consensus of all group members for a shared grade *and* in the delivery of a shared grade for students' comprehension assessment performance which was devised by averaging the grades of the students in each small group.

Theoretically, the instructional arrangements involving positive interdependence should have resulted in learning environments that explicitly motivated students to collaborate and generate work that represented the collective consensus of all group members. While further analysis of the student discourse that was generated during each of the PBL conditions involving a social component must be conducted in order to provide confirmation that this was in fact the case, the aforementioned instructional arrangements utilized in the current study generated outcomes that are in direct conflict with the findings of both Pease and Kuhn (2010) and Wirkala and Kuhn (2011). Specifically, the participants' performance scores were significantly higher during the PBL conditions including a social component compared to the PBL independent condition for three of the four primary sources of data in the current study. It is also important to note that while the results were not statistically significant, the participants' performance scores resulting from the PBL-High PI condition were also the highest for the fourth source of data.

Summary of Results

A comparison between the performance scores obtained during the two experimental conditions involving the social component of PBL (PBL-PI & PBL-High PI) and the experimental condition without a social component (PBL-Independent) demonstrated that there was a statistically significant difference between the outcomes of these different instructional arrangements on three of the four primary sources of data in the current study. Specifically, statistical analyses demonstrated that participant scores on the comprehension assessments, problem solutions, and take-home final examinations that resulted from students' engagement with PBL instruction that involved a social component were significantly higher as compared to the scores on these three measures that resulted from the participants' engagement with the instruction during the PBL-Independent condition. Additionally, while the participant scores resulting from the three experimental conditions were not significantly different on the in-class final examination, participant scores resulting from instruction during the PBL-High PI condition were the highest as compared to the scores resulting from instruction during the other two experimental conditions. Contrary to the findings of Pease and Kuhn (2010) and Wirkala and Kuhn (2011), the results of the current study suggest that the collaborative aspect of PBL may indeed be one of the components of the technique that are essential to the success of students engaged in this form of instruction.

In addition to examining the role of collaboration in the success of students during PBL, the current study examined the influence of varying the degree of positive interdependence inherent in the two PBL conditions that included a social component. The difference in the means of the participant scores resulting from the PBL-PI condition as compared to the PBL-High PI condition was not statistically significant on the two primary sources of data that were

implemented in the last two weeks of the course. Specifically, the participant scores obtained from their performance on the take-home and in-class final examinations, related to the content that was taught during the two PBL conditions involving a social component, did not vary to a statistically significant degree. However, the difference between the means of participant scores related to their performance on the comprehension assessments and the written problem solutions resulting from the two PBL conditions that involved a social component did vary to a statistically significant degree. Specifically, participant scores obtained via the written comprehension assessments resulting from the PBL- High PI condition were significantly higher than those obtained during the PBL-PI condition. On the contrary, participant scores obtained via the written problem solutions resulting from the PBL- High PI condition were significantly lower than those obtained during the PBL-PI condition.

Lastly, it is important to note that statistical analysis demonstrated a significant effect for the interaction between the factors "section" and "instructional design" for three of the four primary sources of data in the current study. Specifically, the interaction term was statistically significant for the scores resulting from the problem solutions, and both final examinations. This outcome could be due to the influence of a number of factors including differences in the sequence of presentation of the different PBL conditions across the sections of the course, individual differences between students, or differences related to the instructor, instructional content, and the instructional environment. While there were several factors that were carefully controlled in the current study, further analysis of the audio/video data that was collected in the is required to provide additional evidence that the instructor, the instructional content, instructional materials, and the time spent on instruction was consistent across participants.

Interpretation of Results

While the results of the current study related to the analysis of participant performance on the four primary sources of data provide a compelling argument for the benefits of adopting a model of PBL instruction that includes a social component to prepare students to be able to provide complex explanations about the academic content to which they have been exposed and apply this content to novel situations, it is important to note that these should not be the only outcomes that are assessed in exploring the overall merits of PBL in its purest form. In judging whether PBL including a social component is an effective means of instruction it is crucial to consider all of the desirable outcomes that this type of instructional arrangement aims to encourage beyond the acquisition of a complex understanding of domain-specific content. It is through this lens that it becomes evident that the conclusions made in the study by Pease and Kuhn (2010) that "social collaboration is not essential to PBL (p.79), and those by Wirkala and Kuhn (2011) that "collaboration is not one of the essential components of PBL" (p.1182) seem to stem from a misunderstanding of the fundamental purpose of adopting a PBL approach.

In both of these previous studies, the researchers found that student performance resulting from PBL including a social component was not significantly different from student performance resulting from PBL without a social component. The researchers interpreted these results to suggest that collaboration does not contribute to the success of the PBL instructional method. While it has been demonstrated that "…collaborating in small tutorial groups indeed facilitates the acquisition of such skills" (Schmidt et al., 2009, p.237), the conclusions drawn by Pease and Kuhn (2010) and Wirkala and Kuhn (2011) fail to consider that the development of skills related to collaboration is a worthwhile goal for students to pursue in its own right. This failure to consider collaboration as a primary instructional outcome is contrary to the recommendations of

proponents of the PBL method who provide that "Collaboration is essential. In the world after school most learners will find themselves in jobs where they need to share information and work productively with others. PBL provides a format for the development of these essential skills" (Savery, 2006, p.13).

The conclusion made by the researchers in the studies by Pease and Kuhn (2010) and by Wirkala and Kuhn (2011) that the lack of difference in student performance during a PBL condition with a social component as compared to a PBL condition without a social component is evidence that demonstrates the lack of contribution of collaboration to the success of the PBL instructional method are in direct conflict with the interpretation of similar results made by several other researchers concerning the effectiveness of PBL (Albanese, 2000; Norman & Schmidt, 2000; Schmidt et al., 2009). These researchers have argued that even if there are no significant differences in domain-specific outcomes between problem-based learning and more traditional forms of instruction that the additional benefits associated with the adoption of PBL beyond the acquisition of static knowledge support its use as an effective form of instruction (Hmelo-Silver et al., 2007). From this perspective, the results of the studies by Pease and Kuhn (2010) and Wirkala and Kuhn (2011) could be interpreted to suggest that while the social component of PBL did not appear to accelerate the acquisition of domain-specific content knowledge, it did nothing to impede it while also providing students with the added benefit of acquiring skills of collaboration.

While there are many variations of PBL currently in use (Maudsley, 1999), many educational researchers would contend that in order for an instructional approach to be considered PBL it must include a collaborative component (Barrows, 1986; Hmelo-Silver, 2004; Savery, 2006). There continues to be many unanswered questions surrounding the potential

benefits of the collaborative component in PBL and the role that collaboration plays in the success of students in PBL environments. Despite the existence of unanswered questions surrounding the specific mechanisms by which collaboration contributes to the success of PBL, it is certain that students solving ill-defined problems in case format in a collaborative small-group format is not pedagogically equivalent to students solving ill-defined problems in case format independently. It is not possible to subtract out the collaborative aspect of PBL without also influencing other aspects of the instructional design thought to contribute to its effectiveness.

For instance, the removal of the social component of PBL has a transformational effect on the role of the teacher or facilitator during PBL instruction. According to Hmelo-Silver and Barrows (2006):

> In PBL the facilitator is an expert learner, able to model good strategies for learning and thinking, rather than providing expertise in specific content. This role is critical, as the facilitator must continually monitor the discussion, selecting and implementing appropriate strategies as needed. As students become more experienced with PBL, facilitators can fade their scaffolding until finally the learners adopt much of their questioning role. Student learning occurs as students collaboratively engage in constructive processing. (p.24)

When students are engaged in active collaboration, the facilitator can survey group progress from any location in the classroom that is within audible range of the group's discussion without interrupting the collaborative process. Without active collaboration between students, the teacher is unable to act as a facilitator of constructive processing because they are no longer able to monitor student progress through passive observation. This renders the teacher powerless to

determine when students are in need of support and the type of support that would best scaffold their learning.

In PBL environments that include a collaborative component, the facilitator can initiate interaction with groups of students for the purpose of supporting their learning through a number of strategies including asking open-ended questions, pushing for explanations, revoicing, summarizing, and generating/evaluating hypotheses (Hmelo-Silver & Barrows, 2006). Interaction between students and their teacher within instructional designs that do not involve a collaborative component are often student-initiated. These interactions occur when a student recognizes that they are stuck and in need of assistance. This aspect of independent "PBL" is problematic in that a student must first recognize that they are not on the right track towards solving the problem at hand in order to realize that they are in need of support from their teacher. Due to the ill-defined nature of problems in PBL, it is possible for students to pursue information provided in the initial case that is erroneous to the derivation of a viable problem solution. This can result in situations where students are under the impression that they are making progress in solving the problem when in reality they are hopelessly astray.

While there are a number of alternate strategies that instructors could adopt to ensure that students receive adequate support during independent forms of learning, none of them provide the instructor with the means to provide support that is identical or equivalent to that which can be provided during collaborative forms of learning in PBL. This fundamental difference related to the role of the instructor in collaborative and independent instructional designs is unavoidable given the social nature of cognitive apprenticeship. Being that the subtraction of the social component from PBL method results in an instructional arrangement that is unrecognizable in

comparison to PBL in its purest form, it is evident that PBL without the collaborative component is not a form of "PBL" at all.

The comparison of participant scores resulting from their performance on the comprehension assessments following the two PBL conditions involving a social component demonstrated that participants performed significantly better during the PBL-High PI condition as compared to their performance on the comprehension assessments following the PBL-PI condition. One explanation for this outcome is that the comprehension assessments used in the current study were designed to measure the acquisition of knowledge related to a complex understanding of domain specific content surrounding the three key topics that were targeted for instruction. Given that the increased structure typically associated with cooperative learning environments is best suited to "accomplish a specific goal or develop an end product which is usually content specific" (Panitz, 1997, p.5), it is not surprising that the PBL condition that involved the greatest amount of teacher-imposed structure in the current study also produced the best performance outcomes on the assessment designed to measure students' level of comprehension related to the domain-specific content acquired through their engagement with PBL instruction.

The comparison of participant scores resulting from their performance on the problem solutions during the two PBL conditions involving a social component demonstrated that participants performed significantly better during the PBL-PI condition as compared to their performance on problem solutions during the PBL-High PI condition. While group outcomes varied depending on the quality of their collaboration, the groups tended to devise problem solutions that more complex, creative, well-written, and clearly linked to the requirements of the problem during the PBL-PI condition as compared to the solutions resulting from the PBL-High

PI condition. For example, the explanation of cognitive learning theory that was provided in a problem solution resulting from the PBL-High PI condition by a group that struggled with the collaborative aspect of PBL was "I believe that the most effective study plan for Charlie incorporates many aspects of the Cognitive Learning Theory because this theory acknowledges how the environment affects and forms the mind" (see Appendix J p. 159). This explanation is vague, lacks detail, and does little to demonstrate the students' understanding of cognitive learning theory. In contrast, the explanation of cognitive learning theory that was provided in a problem solution resulting from the PBL-PI condition by a group that exceled throughout the collaborative aspect of PBL was "The cognitive learning theory is the relationship between the individual and the individual's perception of the environment. Everyone interprets information differently because of their prior life experience. As a result, everyone learns differently" (see Appendix K p.161). This explanation specifically describes the mechanism by which learning occurs according to cognitive learning theory and provides evidence that the students have a clear understanding of this concept.

These results could be interpreted as supporting the concern raised by Sweller, Kirschner, and Clark (2007) that collaboration in student-centered instructional designs like PBL "imposes costs in terms of cognitive load" (p.117). From this perspective, it is possible to explain the significantly lower problem solution scores that resulted from the PBL-High PI condition in the current study in terms of the finite nature of cognitive load. If the degree of collaboration between group members has an influence on the amount of cognitive load that students' experience as a result of their collaborative effort, then it can be inferred that as the quality of collaboration increases cognitive load also increases. If a student's capacity for cognitive load is finite, than tasks that draw a large cognitive load may interfere with the student's ability to

perform multiple tasks at once. In this way, the significantly lower problem solution scores resulting from the PBL-High PI condition in the current study may be indicative of a significant increase in the rigor and quality of collaboration among students working in small groups.

The written problem solutions utilized in the current study are only an approximation of the outcomes of collaborative engagement among students working in small groups during the PBL conditions involving a social component. The composition of an essay explaining a collaborative group's collective solution to an ill-defined problem can be viewed as being a secondary outcome to the actual collaboration that occurs in real-time during this process. Thus, as the quality of collaboration goes up, cognitive load also goes up and students' capacity to complete academic tasks peripheral to the actual development of a problem solution may be impaired. It is important to note that while it is hypothesized that a higher degree of positive interdependence could result in higher quality collaboration, further analysis of student discourse that occurred during the experimental conditions involving a social component in current study is necessary to confirm this relationship. This further analysis (while outside the scope of this dissertation) will be one of the primary focuses of future research involving a qualitative discourse analysis of the audio and video data that was collected during the current research.

An alternative explanation for the lower problem solution scores acquired during the PBL-High PI condition could be that the increase in structure and individual accountability provided by the instructional arrangement may have undermined the collaborative process resulting in groups developing less complex solutions to the problems. According to Brufee (1995):

> The major disadvantage of cooperative learning is that in guaranteeing accountability, it risks maintaining authority relations within each small working group and in the class as

> a whole that replicate the authority relations of traditional education…cooperative-learning pedagogy tends to undercut collaborative learning's aim to shift the locus of authority from the teacher to student groups. (p.5)

From this perspective, the results of the current study suggest that while it may be important to embed some aspects of positive interdependence into the design of collaborative learning environments as a means of scaffolding the development the skills necessary for high-quality collaboration, there may be a tipping point at which too much teacher-imposed structure actually jeopardizes the positive outcomes of the collaborative process.

The findings of the current study have vast implications for the design of PBL environments across academic disciplines and levels. Specifically, the findings suggest that the key ingredient to ensuring student success in collaborative learning environments may rest on providing an appropriate degree of structure to scaffold student development of skills related to the collaborative process. It is hypothesized that this would be particularly important when introducing students to collaborative forms of learning for the first time. However, it is also important that educators match the level of structure that is embedded in collaborative designs to the learning outcomes that they wish their students to achieve. For instance, in the current study a higher degree of positive interdependence embedded within the instructional design resulted in superior performance scores on written assessments designed to measure the depth of students' comprehension of domain-specific content and lower scores resulting from the students' performance on the problem solution tasks. Based on these outcomes, it is important for practitioners in education to attempt to strike a balance between providing students with the support they need in order to be successful during the collaborative process, and avoid providing too much support inadvertently undermining the benefits of collaboration.

Limitations and Directions for Future Research

While there were several aspects of the design of the current study that were meant to foster experimental control within a "real" classroom environment, research conducted in these types of settings are highly contextualized due to the dynamic nature of teaching and learning. Additionally, as is typical of the majority of research conducted within authentic educational settings, the participants in the current study did not constitute a randomized sample. These factors potentially undermine the degree to which the findings of the current study are generalizable to other learning environments and students at various levels.

Additionally, there are limitations related to the primary instructor for the educational psychology course also being the principle investigator in the current study. While every effort was made to ensure that the behavior of the instructor was consistent across the three sections of the course and the experimental conditions involving PBL with a social component, further analysis of the data that were collected via multiple audio/visual recording devices is required to confirm that the instructor did not unconsciously favor any one of the sections of the course or instructional arrangements over any of the others. Future research could minimize this limitation by ensuring that the principle investigator does not also serve as the primary facilitator of instruction. Additionally, these concerns could be addressed even further by only providing the facilitators of PBL with the information required to implement instruction, but not briefing them on the purpose of the research until after all data has been collected.

Despite there being several different sources of data for analysis in the current study, the examination of participant performance on the comprehension assessments, two final examinations, and written problem solutions did not provide a direct means of evaluating the benefits resulting from PBL beyond the acquisition of domain-specific content. While the

findings of the current study support the inference that that the PBL arrangements including a social component contributed to students' development of skills beyond the acquisition of content-based knowledge, there is not adequate evidence to support specific conclusions related to the degree to which students were encouraged to develop skills such as "epistemic practices, self-directed learning, and collaboration that are not measured on achievement tests but are important for being lifelong learners and citizens in a knowledge society" (Hmelo-Silver et al., 2007, p.105).

Further research is required towards the identification and measurement of learning outcomes that result from collaborative PBL instruction that are not well captured via traditional assessment formats. Specifically, it is crucial that future studies aim to document the outcomes that result from students' engagement in PBL that includes a social component regarding the development of skills related to collaboration, self-direction, and flexible knowledge. Additional research should also focus on methods for increasing the degree and quality of collaboration that occurs among members of small groups during PBL and examining the associated costs and benefits of doing so. This research should also seek to identify indicators of high-quality collaboration as a means of understanding the discrepant findings of research regarding the effectiveness of PBL instructional designs.

Additional research is required to fully understand the relationship that exists between the degree and amount of structure that is embedded in collaborative learning designs and the outcomes that result. The current study explored this relationship by examining the performance of students during and following their exposure to collaborative learning with varying degrees of positive interdependence. Future studies should endeavor to identify and examine other ways of

achieving a balance between encouraging individual accountability without undermining the collaborative process within PBL environments.

Conclusions and Implications of the Current Research

> One of the most fundamental obligations of any society is to prepare its adolescents and young adults to lead productive and prosperous lives as adults. This means preparing all young people with a solid enough foundation of literacy, numeracy, and thinking skills for responsible citizenship, career development, and lifelong learning…The American system for preparing young people to lead productive and prosperous lives as adults is clearly badly broken. Millions of young adults now arrive at their mid-20s without a college degree and/or a route to a viable job. (Symonds, Schwartz, & Ferguson, 2011, p.1)

Despite the unprecedented expansion of colleges and universities and a clear alignment of the relationship between secondary and higher education within the United States, America is yet to realize a national system of education that meets the demands of all students regardless of their future goals. The combination of a "college preparation for all" mentality and the commoditization of education have resulted in devalued credentials for few and employment for fewer. The 60% of the US population that are unable to gain admission to higher education (Symonds, et al., 2011) and the 19% of young Americans that are currently unemployed (Aud, KewalRamani, & Frohlich, 2011) are often left with "rigorous academic training" to show for their 12+ years spent in classrooms via compulsory education, and none of the skills that would actually get them a job or lead to a better life. According to a report released by the Graduate School of Education at Harvard University, "The percentages of teens and young adults who are

working are now at the lowest levels recorded since the end of the 1930s Depression" (Symonds, et al., 2011, p.5).

The Pathways to Prosperity Report suggests that "Our current system places far too much emphasis on a single pathway to success: attending and graduating from a four-year college". Given that only approximately 30% of students actually earn a bachelor's degree by age 27, it is a narrow pathway indeed (Symonds, et al., 2011). In our modern world of technological advancement and globalization, it has become increasingly difficult to anticipate the specific academic content that will be of most use in preparing students for success in the decades to come (Kuhn, 2007). This, in addition to the aforementioned concerns related to the outcomes that result from the current system of US education, have driven some to suggest that "we are now at a point at which we should focus attention on what it is that students may be motivated to learn and why they wish to do so" (Kuhn, 2007, p.112) and that "the only defensible answer to the question of what we want schools to accomplish is that they should teach students to use their minds well, in school and beyond" (Kuhn, 2007, p.110).

Research focusing on evaluating the effectiveness of instructional designs that involve the development of skills best suited to prepare learners for success in a rapidly changing world is timely given the urgency with which many stakeholders in US education are calling for a reevaluation of the objectives of the institutions serving our students. Instructional designs that promote skills related to critical thinking, problem solving, collaboration, and self-direction in additional to encouraging students to acquire flexible knowledge about specific content via the approximation of real-world situations are well-positioned to meet these needs.

The current study contributes to the mission of identifying the educational practices that are best suited to accomplish the goal of preparing students to for successful outcomes in life by

examining the aspects of problem-based learning that contribute to its effectiveness. This type of research is essential, as it is imperative that educators at all levels choose to implement instructional strategies that are empirically based. Ideally, the outcomes reported in the current study will provide some degree of clarity and direction as to the instructional methods that constitute educational "best practice" in the implementation of PBL instruction.

The findings of the current study suggest that the collaborative aspect *is* an indispensable component of PBL and that it is crucial to the success of students engaged in this type of instruction. This has vast implications for the way that the design of PBL curriculum and instruction should be approached across academic disciplines. Specifically, the findings of the current study confirm that PBL is most effective when implemented in its purest form, and that problem-based instructional designs without a collaborative component cannot be considered as a pedagogically equivalent alternative to problem-based learning as it is commonly defined. Additionally, the findings of the current study suggest that in order to encourage the success of their students in PBL environments, educators must match the degree of structure that is embedded in the instructional design to the outcomes that they view as being most important. Lastly, the current study provides a model for practitioners in utilizing the framework provided by social interdependence theory as a means of providing the scaffolding necessary to encourage high-quality collaboration among students working in small groups during PBL.

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Appendices

Appendix A:

Manente Educational Psychology Spr2013

Problem Solution Pre-Assessment

Date:_____

Student Name:_____

Instructions: Answer the following questions to the best of your ability without the use of any outside sources. This assessment should be completed individually.

1: Explain cognitive theories of learning. Identify and describe specific concepts related to this perspective and discuss how they might influence the acquisition of knowledge.

2**:** Explain social constructivist theories of learning. Identify and describe specific concepts related to this perspective and discuss how they might influence the acquisition of knowledge.

3**:** Explain behavioral learning theory. Identify and describe specific concepts related to this perspective and discuss how they might influence the acquisition of knowledge.

Appendix B:

Manente Educational Psychology Spr2013

Practice Problem

Date:_____

Student Name:_____

Group Number:_____

Instructions: Use the following information to complete the provided problem identification and information gathering worksheet with the other members of your group.

You are the parent of 10 year old twin boys. You have decided to take them on a weekend trip to one of the largest metropolitan zoos in the US which just so happens to be within driving distance from your home. Being that you are passionately committed to their growth as students of the world you want to devise a plan to ensure that they learn as much as possible from the trip. You do not just want them to memorize random facts; you want them to devise questions based on their surroundings and think deeply about all that they will see. In order to be sure that this happens you have decided to use Bloom's Taxonomy to design a number of activities for your children to engage in before, during, and after your trip to the zoo. Compose an itinerary or outline of your plan which includes a detailed description of each of the activities and what you hope that your children will gain. Every level of Bloom's taxonomy should be addressed by some aspect of your plan. Be sure to include some method of formal or informal assessment in order to gauge the success of your teaching strategies.

Appendix C:

Manente Educational Psychology Spring2013

Practice Problem: Problem Identification and Information Gathering Phase Worksheet

Date:_____

Student Names:_____

Group Number:_____

Instructions: The responses for each section should be representative of the collective consensus of all members of the group.

1. What is the problem that must be solved?

2. What facts/information do you already have that can help you complete the application?

3. What are the specific questions that you must address in order to solve the problem?

4. What are the things that you still have to learn in order to answer these questions? List any terms, ideas, concepts, or theories related to the questions that you wrote that you must learn more about.

5. Where will you look to find any additional information that you need?

6. Use the following space to draft an outline related to how you plan to address the identified problem. This can be in paragraph or bulleted form.

Manente Educational Psychology Spring 2013

Practice Problem: Problem Solution Worksheet

Date:_____

Recorder Name:_____

Group Number:_____

Instructions: The responses for each section should be representative of the collective consensus of all members of the group.

Section I: Introduction

Guiding Questions:

What do you want your children to learn from their trip to the zoo?

Section II: Review of Bloom's Taxonomy

Guiding Questions:

What is Bloom's Taxonomy?

How will you use the taxonomy to design instruction related to the trip to the zoo?

Section III: Description of Specific Methods for instruction, assessment, etc.
Guiding Questions:
Where will instruction take place?
Will instruction occur before, during, after, or throughout the trip?
What specific strategies will you use to encourage your children to learn?
How will you measure their performance?
Have you integrated every level of the taxonomy in your instruction?

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Sample Scoring Rubric

THIS SECTION TO BE COMPLETED BY INSTRUCTOR

Date:_____

Group Number:_____

Score: _____/10

9-10 Points	7-8 Points	5-6 Points	0-4 Points
Response has a clear direction/topic/thesis supported by relevant literature.	Response has a thesis but does not remain consistent throughout.	Response does not have a clear thesis.	Response has no thesis.
Demonstrates appropriate use of psychological theory to justify response.	Minor errors in the application of psychological theory to justify response.	Appropriate/correct application of psychological theory is minimal.	Little or no use of psychological theory to justify response.
The response thoroughly addresses all aspects of the problem.	Some aspects of the problem are not addressed in full.	The stated problem is largely unaddressed by the proposed solution.	The problem is not addressed by the proposed solution.
The proposed solution/instructional plan is pedagogically sound.	There are minor limitations regarding the utility of the proposed solution	The proposed solution is not practical or pedagogically sound.	There are no specific recommendations for classroom implementation
Response is clearly written with no grammatical or spelling errors.	Response contains a few grammatical or spelling errors.	Response has several grammatical errors, inconsistent sentence structure, spelling errors, or writing is unclear at times.	Incomplete sentences, grammatical and spelling errors throughout the response. Writing is awkward and largely unclear.

Appendix D:

Manente Educational Psychology F2012

Problem I

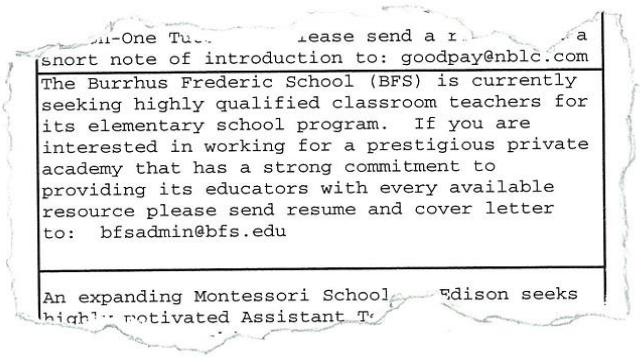
Date:_____

Student Name:_____

Group Number:_____

Instructions: Use the following information to complete the provided problem identification and information gathering worksheet with the other members of your group.

You are a recent graduate of a well-respected teacher preparation program. Now that you have completed your coursework, passed the praxis, and gotten your certification to teach elementary school it is time to find a job. While flipping through the Star Ledger you see the following advertisement announcing several openings at a prestigious private institution of elementary education called the Burrhus Frederic School (BFS).



You respond to the advertisement by sending an email message to the address provided, with your most current resume attached. In your email, you state that you are very interested in joining the BFS team and would appreciate the opportunity to meet to learn more about a teaching position. Four days later the attached letter arrives at your home.

Greetings and thank you for your interest in joining our team!

We currently have the following openings at BFS:

1st Grade Classroom Teacher

5th Grade Classroom Teacher

At the Burrhus Frederick School, we strongly believe that learning is best defined as the acquisition of various measurable and observable responses, skills, or abilities, academic or otherwise, as a direct result of environmental influence. We are committed to ensuring that our students are well prepared to perform at a high level of accuracy on many common concrete measures of academic achievement.

The administration at BFS is dedicated to the recruitment of only the finest educators whose philosophical orientation and skill sets are well aligned with these core beliefs. To this end, we expect that all applicants specify which open position they are interested in and submit a 3-5 page plan of instruction outlining how they would design their classroom and tailor instructional methods to reflect the fundamental values of the Burrhus Frederick School. At minimum, this plan should specifically address if/how you intend to utilize the concepts of reinforcement, punishment, and shaping to support the academic development of your students relative to classroom organization, management, and teaching.

We look forward to meeting with you to discuss your completed application.

All the best,

BFS Administration

Appendix E:

Manente Educational Psychology F2012

Problem I: Problem Identification and Information Gathering Phase Worksheet

Date:_____

Recorder Name:_____

Group Number:_____

Instructions: The responses for each section should be representative of the collective consensus of all members of the group.

1. What is the problem that must be solved?

2. What facts/information do you already have that can help you complete the application?

3. What are the specific questions that you must address in order to solve the problem?

4. What are the things that you still have to learn in order to answer these questions? List any terms, ideas, concepts, or theories related to the questions that you wrote that you must learn more about.

5. Where will you look to find any additional information that you need?

6. Use the following space to draft an outline related to how you plan to address the identified problem. This can be in paragraph or bulleted form.

Manente Educational Psychology F2012

Problem I: Problem Solution Worksheet

Date:_____

Recorder Name:_____

Group Number:_____

Instructions: The responses for each section should be representative of the collective consensus of all members of the group.

Section I: Introduction

Guiding Questions:

Does this section include a brief overview of your instructional philosophy?
Is the theme and purpose of your paper clearly articulated?

Section II: Review of Relevant Theory & Literature

Guiding Questions:

Have you identified a theoretical framework that is complimentary to the values of BFS?

Does your discussion of this framework demonstrate your understanding of its fundamental concepts?

Section III: Description of Specific Methods for Classroom Organization, Instruction, Assessment, etc.
Guiding Questions:
What will your classroom look like?
What specific strategies will you use to encourage your students to learn?
How will you measure their performance?
Is your proposed instructional plan compatible with the values of BFS?

Section IV: Conclusion
Guiding Questions:

Is the theme/purpose of the paper clear and consistent throughout?
Have you made a compelling argument that you are the best candidate for this particular position?

Manente Educational Psychology SPR2013

Problem I: Scoring Rubric

THIS SECTION TO BE COMPLETED BY INSTRUCTOR

Date:_____

Group Number:_____

Score: _____/10

9-10 Points	7-8 Points	5-6 Points	0-4 Points
Response has a clear direction/topic/thesis supported by relevant literature.	Response has a thesis but does not remain consistent throughout.	Response does not have a clear thesis.	Response has no thesis.
Demonstrates appropriate use of psychological theory to justify response.	Minor errors in the application of psychological theory to justify response.	Appropriate/correct application of psychological theory is minimal.	Little or no use of psychological theory to justify response.
The response thoroughly addresses all aspects of the problem.	Some aspects of the problem are not addressed in full.	The stated problem is largely unaddressed by the proposed solution.	The problem is not addressed by the proposed solution.
The proposed solution/instructional plan is pedagogically sound.	There are minor limitations regarding the utility of the proposed solution	The proposed solution is not practical or pedagogically sound.	There are no specific recommendations for classroom implementation
Response is clearly written with no grammatical or spelling errors.	Response contains a few grammatical or spelling errors.	Response has several grammatical errors, inconsistent sentence structure, spelling errors, or writing is unclear at times.	Incomplete sentences, grammatical and spelling errors throughout the response. Writing is awkward and largely unclear.

Appendix F:

Manente Educational Psychology SPR2013

Problem II

Date:_____

Student Name:_____

Group Number:_____

Instructions: Use the following information to complete the provided problem identification and information gathering worksheet with the other members of your group.

You are a third-year undergraduate student at a large state-funded university that is supported primarily by public sponsorship. The governing body of the state in which you are attending school determines that the majority of the funding that is usually allotted to support your university's budget would be better allocated towards repairing various aspects of the state's aging infrastructure. Facing the possibility of financial collapse, the university opts to increase undergraduate student tuition by fifty percent in order to recoup some of the lost funding.

You have not planned for the possibility of a significant increase in tuition costs. After crunching the numbers and estimating the costs for books, fees, and room and board, you know that you will not be able to afford to maintain your student status throughout the upcoming semester with your current income. You decide that you need an additional source of funds to pay your way through school and you begin reviewing job postings on craigslist on a regular basis. One particular post within the education jobs section draws your attention:

Looking for SAT Writing and Reading Tutor (New Brunswick, NJ)

Date: 2012-09-21, 11:03PM EDT
Reply to this post nrfsgnx-3301555587@job.craigslist.org [Errors when replying to ads?]

The tutor should have excellent SAT scores and teaching/tutoring experience. Each lesson is 2 hours. If interested, please respond to samnemonic7@email.com

- Location: New Brunswick, NJ
- Compensation: $80 per two hours
- This is a part-time job.
- Principals only. Recruiters, please don't contact this job poster.
- Please do not contact job poster about other services, products or commercial interests.

PostingID: 3350156235535287

Since you have good SAT scores and you have taken some education courses, you decide that the pay is too good not to give it a shot. You respond to the email address provided and state that you are interested in the job. You receive the following email response the next day:

Manente Educational Psychology F2012

-------- Original Message --------

Subject: SAT Tutor

Date: Thu, 22 Nov 2012 06:50:44 -0500 (EST)

From: samnemonic7@email.com

To:you@RUTGERS.EDU

Hello,

I am looking for a tutor for my son Charlie that can spend some time helping him for a few sessions a week, but that can also design a study program that I can use to help Charlie myself when the tutor is not around. Charlie is getting ready to take the SAT test and what he really needs is to learn the vocabulary words that he will see on the test. I have a list of 500 words that are most likely to appear on the test and I would like someone to help him become more familiar with the terms and their definitions.

Charlie has been studying for the past month or so but he can't seem to remember anything after he has read it. He just seems to forget everything right after he finishes studying. Our deal is that he has to study for two hours every night but that he is allowed to have the TV and his laptop on while he is studying.

I am the type of person that doesn't just like to be able to do something, I really like to know how everything that I am doing is working. In order for me to be able to help him when the tutor is not around, I want a very clear study plan that provides some strategies for Charlie but that also explains how the study strategies are working. I just read an article in an education magazine that said that all instructional strategies should be based on theories and have research backing them up so I would want the plan to include some of that.

Another article in the same magazine said that in order to learn something new we have to associate it with something that is already in our long-term memory and that you can use something called the keyword strategy to do it. I think that Charlie is having trouble with processing all of the information. I really think that for some reason all the words and definitions are not making it into his memory banks and he needs some new study strategies to help him.

Maybe you could put together a draft of what you have in mind for Charlie's study plan? I am pretty busy right now, so I would really like it to be short and to the point but still have all of the stuff that I mentioned in it. I would think that three to five pages should do the trick. I can meet with you to go over your plan two weeks from today. Please let me know if you are interested.

Nancy Coding

Appendix G:

Manente Educational Psychology F2012

Problem II: Problem Identification and Information Gathering Phase Worksheet

Date:_____

Recorder Name:_____

Group Number:_____

Instructions: The responses for each section should be representative of the collective consensus of all members of the group.

1. What is the problem that must be solved?

2. What facts/information do you already have that can help you form a solution?

3. What are the specific questions that you must address in order to solve the problem?

4. What are the things that you still have to learn in order to answer these questions? List any terms, ideas, concepts, or theories related to the questions that you wrote that you must learn more about.

5. Where will you look to find any additional information that you need?

6. Use the following space to draft an outline related to how you plan to address the identified problem. This can be in paragraph or bulleted form.

Manente Educational Psychology SPR2013

Problem II: Problem Solution Worksheet

Date:_____

Recorder Name:_____

Group Number:_____

Instructions: The responses for each section should be representative of the collective consensus of all members of the group.

Section I: Introduction

Guiding Questions:

Does this section include a brief overview of your proposed study plan?

Do you identify the underlying theory/philosophy that was used to develop your plan?

Section II: Review of Current Study Habits and Detailed Discussion of Theory Underlying the New Plan

Guiding Questions:

Have you examined and described aspects of the current system that are good and those that are in need of improvement?
Do you explain your findings in the context of a relevant theoretical framework?
Does this section include a detailed discussion of this framework that demonstrates your understanding of its fundamental concepts?

Section III: Description of the Proposed Study Plan

Guiding Questions:

What are the specific learning goals that you will set for Charlie?
What specific instructional techniques will you encourage him to use to obtain these goals?
Are all aspects of the proposed plan compatible with the theoretical framework that you have described?

Section IV: Conclusion
Guiding Questions:

Is the theme/purpose/voice of the paper clear and consistent throughout?
Is this a plan that Charlie's mother could reasonably implement with success based on your instructions?

Manente Educational Psychology SPR2013

Problem II: Scoring Rubric

THIS SECTION TO BE COMPLETED BY INSTRUCTOR

Date:_____

Group Number:_____

Score: _____/10

9-10 Points	7-8 Points	5-6 Points	0-4 Points
Response has a clear direction/topic/thesis supported by relevant literature.	Response has a thesis but does not remain consistent throughout.	Response does not have a clear thesis.	Response has no thesis.
Demonstrates appropriate use of psychological theory to justify response.	Minor errors in the application of psychological theory to justify response.	Appropriate/correct application of psychological theory is minimal.	Little or no use of psychological theory to justify response.
The response thoroughly addresses all aspects of the problem.	Some aspects of the problem are not addressed in full.	The stated problem is largely unaddressed by the proposed solution.	The problem is not addressed by the proposed solution.
The proposed solution/instructional plan is pedagogically sound.	There are minor limitations regarding the utility of the proposed solution	The proposed solution is not practical or pedagogically sound.	There are no specific recommendations for classroom implementation
Response is clearly written with no grammatical or spelling errors.	Response contains a few grammatical or spelling errors.	Response has several grammatical errors, inconsistent sentence structure, spelling errors, or writing is unclear at times.	Incomplete sentences, grammatical and spelling errors throughout the response. Writing is awkward and largely unclear.

Appendix H:

Manente Educational Psychology SPR2013

Problem III

Date:_____

Student Name:_____

Instructions: Use the following information to complete the provided problem identification and information gathering worksheet.

You are the coordinator of a summer camp sponsored by the local community center in the Zuni Pacific Delta (ZPD) Township. The center exists to serve the municipalities of the ZPD by ensuring that all residents are well- informed regarding important social issues that are relevant to their everyday lives. Additionally, one of the core missions of the center is to ensure that every person residing in the township has the opportunity to become educated in what it means to be a good citizen. Being an organization devoted to education, the center has a set of guiding principles related to the types of outcomes that are of most importance and the types of instructional practices best suited to reach these outcomes. These principles are as follows:

1. Learning environments should encourage individuals to construct knowledge by interacting with their surroundings and their peers.

2. There should be a particular emphasis on promoting the meaning-making that can only be derived from collaboration and social interactions that occur between individuals.

3. Individuals should be expected to direct their own learning while becoming competent collaborators, problem solvers, and life-long learners.

4. The primary focus of instruction should be on promoting higher-order thinking as opposed to the rote memorization of factual content as a means to an ends.

Your boss, the director of the center, has come up with an idea for a new initiative that he hopes will make a significant impact on your township. His plan focuses on involving the children that attend your summer camp in some form of community service project that will instill a sense of citizenship and encourage them to be socially aware. The director just recently sent you the following memo in which he has nominated you to spearhead this new initiative and outlined some of the basic requirements for the project.

Hey,

I just thought that I would share some good news with you. I don't know if you remember that idea about the community service project that I brought up in our last staff meeting, but I just got the green light to move forward and I have decided that you would be the perfect person to really get it off the ground.

I think that the project would be a great way for our middle school aged campers to get to know more about their community. I am pretty open to the types of projects that the campers should do. I suppose we could have them do a bunch of small projects over the course of the summer or one big one. The important thing is that you remember that the whole purpose of the project is to encourage our children to work together alongside their counselors in order to have a sense of collective efficacy.

The campers should get some form of instruction about the types of things that you will ask them to do. As always, your instructional plan should be based on all of our guiding principles. Furthermore, the tasks or project(s) that you propose should be authentic and meaningful to the campers' lives and should benefit all the residents of the township in some way.

Please develop a proposal for the program and have it to me by next week. The proposal should include: 1. A clear mission statement and philosophy for the summer camp program. 2. A description of the theory on which these are based and a discussion of the fundamental learning objectives that the center will encourage campers to meet. 3. A general outline of the type of instructional practice that will be adopted by the counselors center-wide. 4. An example of a specific instructional plan. 5. A detailed outline of the types of community service projects that the campers will engage in.

I know that you are going to be as excited about this project as I am. I am really looking forward to reading your proposal next week.

Your Boss,

The Director

Appendix I:

Manente Educational Psychology SPR2013

Problem III: Problem Identification and Information Gathering Phase Worksheet

Date:_____

Student Name:_____

Instructions: The following questions should be completed individually. You should not discuss any aspect of your work with the other students in the course.

1. What is the problem that must be solved?

2. What facts/information do you already have that can help you form a solution?

3. What are the specific questions that you must address in order to solve the problem?

4. What are the things that you still have to learn in order to answer these questions? List any terms, ideas, concepts, or theories related to the questions that you wrote that you must learn more about.

5. Where will you look to find any additional information that you need?

6. Use the following space to draft an outline related to how you plan to address the identified problem. This can be in paragraph or bulleted form.

Manente Educational Psychology SPR2013

Problem III: Problem Solution Worksheet

Date:_____

Recorder Name:_____

Group Number:_____

Instructions: The responses for each section should be completed individually.

Section I: Introduction

Guiding Questions:

Does this section include a brief overview of your proposed plan?
Have you included a clear mission statement?

Section II:

Guiding Questions:

Do you identify the underlying theory/philosophy that was used to develop your mission statement/plan?
Does this section include a detailed discussion of this framework that demonstrates your understanding of its fundamental concepts?
Have you identified and explained the fundamental learning objectives for your plan?

Section III: Description of the Proposed Plan

Guiding Questions:

What general/specific instructional techniques will you use to encourage campers to obtain these goals?
Are all aspects of the proposed plan compatible with the theoretical framework that you have described?
Have you included a detailed outline of the types of community service projects the campers will engage in?

Section IV: Conclusion
Guiding Questions:

Is the theme/purpose/voice of the paper clear and consistent throughout?
Is your plan pedagogically sound?

Manente Educational Psychology SPR2013

Problem III: Scoring Rubric

THIS SECTION TO BE COMPLETED BY INSTRUCTOR

Date:_____

Group Number:_____

Score: _____/10

9-10 Points	7-8 Points	5-6 Points	0-4 Points
Response has a clear direction/topic/thesis supported by relevant literature.	Response has a thesis but does not remain consistent throughout.	Response does not have a clear thesis.	Response has no thesis.
Demonstrates appropriate use of psychological theory to justify response.	Minor errors in the application of psychological theory to justify response.	Appropriate/correct application of psychological theory is minimal.	Little or no use of psychological theory to justify response.
The response thoroughly addresses all aspects of the problem.	Some aspects of the problem are not addressed in full.	The stated problem is largely unaddressed by the proposed solution.	The problem is not addressed by the proposed solution.
The proposed solution/instructional plan is pedagogically sound.	There are minor limitations regarding the utility of the proposed solution	The proposed solution is not practical or pedagogically sound.	There are no specific recommendations for classroom implementation
Response is clearly written with no grammatical or spelling errors.	Response contains a few grammatical or spelling errors.	Response has several grammatical errors, inconsistent sentence structure, spelling errors, or writing is unclear at times.	Incomplete sentences, grammatical and spelling errors throughout the response. Writing is awkward and largely unclear.

Appendix J:

Dear Nancy Coding,

Based on your previous letter, I have carefully analyzed your son's current study habits. I believe that the most effective study plan for Charlie incorporates many aspects of the Cognitive Learning Theory because this theory acknowledges how the environment affects and forms the mind. As a result, your son's short and long-term memory will be thoroughly exercised and trained. I have constructed a possible study plan for Charlie. Not only does this plan utilize many useful strategies, it is also accessible without my supervision and will continue to be effective long term.

While reviewing Charlie's current study habits, based on the *Cognitive Learning Theory*, I've noticed that there are good habits and some that need to be improved. I believe that the distributive practice of studying 2 hours each day for a month has been beneficial. Another aspect of Charlie's study habits is that he has a goal: learning 500 vocab words is an instance of declarative knowledge.

After reviewing the information provided, here are a few study habits that need improvement. Study habits that need improvement include: too much interference, decay of information, and using tried and true encoding strategies utilized. Charlie is not retaining information because there is interference during his study sessions. He is too distracted during his study session because he is also watching TV and utilizing the computer. Following the study session, he is at loss of memories because during that time, other sensory information such as TV and computer, are also presented – this is the optimal example of interference. Another problem in Charlie's study habits is that he is not utilizing the vocabulary words outside of the two-hour sessions. This is called decay, a loss of memories when information is not being used. Using SAT vocab in every day life would prevent him from losing the information. Lastly, the student does not recall info because he is not utilizing study strategies or methods. By using such strategies as chunking and elaborative rehearsal, he will not only recognize words but also relate them to his own experiences, which utilizes semantic memory and elaboration.

Cognitive theory has proven that utilizing the following strategies will maximize is learning and rid of decay. *Decay* is the information that is lost because it is not used. The following theories Charlie could utilize are maintenance rehearsal. This theory suggests that Charlie repeats on loop of the study material over and over trying to ensure the vocab words are moving from short-term memory to the long-term memory. Charlie will repeat the vocab words within his two-hour session and daily sessions. *Elaborative rehearsal* is connecting the new vocab words to something already well known. We will discuss with Charlie the likes and dislikes and personal experiences to connect

the vocab words. *Serial position effect* is losing the information based on where the words are on the list. Charlie is more likely to remember the words at the end of the list then the beginning. The words that Charlie seems to struggle with will be put on the end of the list so he can keep the words in his memory. *Mnemonic strategies* can be extremely helpful for Charlie. Some mnemonic strategies are ways to make the words meaningful using strategies such as *acronyms*, which relate the letters of a word with the vocab words. Also, *keyword relates* pictures to the vocab words. Another strategy is *elaboration*, which is when the student applies existing knowledge from their long-term memory to the newly learned word by constructing a story or a picture relating to the word.

Please keep in mind the strategies mentioned above are only a small piece of the pie. These cognitive learning methods are guaranteed to help your son get out of the ditch that is short-term memory and onto land that is long-term memory. By exploiting these heavily researched items, Charlie can now take his environment and apply them to his learning experience. No longer is the vocabulary just a word on a page but a tool to be used in his day-to-day life. You, as a parent, can consistently help Charlie by engaging him in practice. Such simple methods as asking him to use newly learned words in a sentence or to describe his favorite / least favorite TV shows, movies, and web links using the terms. It is of import that Charlie strives for 25 words a week. As long as he is employing *distributed practice*, or spreading his study and use out over the course of the week, Charlie should find it an easier task to remember the once forgotten words.

Appendix K:

Problem II: Problem Solution

Section 1: Introduction

Dear Nancy Coding,

I am responding to your job posting on Craigslist looking for writing and reading tutor. I have some great ideas to help Charlie study for his SAT according to the Cognitive Learning Theory. The cognitive learning theory is the relationship between the individual and individual's perception of the environment. Everyone interprets information differently because of their prior personal life experience. As a result, everyone learns differently.

I noticed some flaws of Charlie's current study plan according to this theory such as his divided attention with the computer and television. He does not rehearse the information he learned every day and has way too many words to learn at one time. With the amount of information he needs to learn, he is having a hard time transferring the information from short term memory to working memory to long term memory. My study plan for Charlie includes using ways to focus Charlie's attention, mnemonic strategies, and ways to easily transfer information from working memory to short term memory to long term memory. Also, I have strategies that you can use at home.

Section II: Review of Current Study Habits and Detailed Discussion of Theory Underling the New Plan

According to the Cognitive Learning theory, we process information by developing internal representations of the external world. We use our perception or our interpretation of events in the environment. We also focus our attention on information that we deem as important. We process this information by using our four different types of memory systems. These memory systems are sensory memory, short term memory, working term memory, and long term memory.

Sensory memory is how we process information that we interpret using our five senses. Short term memory is temporary, limited storage and duration of information. When it is not actively processed, the information will be lost. This active processing takes place in our working memory. Although working memory is also has short term storage, with working memory you can manipulate information you have gained previously to actively use. When information is transferred from working memory to long term memory the information capacity and duration is endless and you can use this information becomes common knowledge.

Using this information, I have determined that some of Charlie's study habits are hindering his learning. The information he is learning is encountering interference though the use of computer and television is decaying because of lack of use, and is not being transferred from short term to long term memory. Attention is ultimately selective and involves simultaneous experiences. He is not encoding information due to his divided attention otherwise known as interference, which is known as the Attenuation Model (Tresiman 1960). Interference is the loss of memory because of the presence of other information. He is not using the information in his everyday life therefore his information is decaying or being forgotten. He is also not transferring information from short term to long term memory because of his lack of maintenance and elaborative rehearsal. Lastly, Charlie is having a hard time remembering the large amount of

words he has been given to memorize at once. He is too overwhelmed because of massed practice.

Section III: Description of the Proposed Study Plan

I plan on having Charlie cease to use his television and computer during study time. This idea of "all or none focusing" can be described by the filter theory of attention, which was introduced by Broadbent (1958). I also think that Charlie needs rehearsal at the end of his study sessions because short term memory only last 20 to 30 seconds at a time. There are two types of rehearsals: maintenance rehearsal and elaborative rehearsal. Maintenance is a cognitive process in which information in working memory is repeated to one self. I will be focusing more on elaborative rehearsal which involves remembering information by connecting it to something already know. Mnemonic strategies are an example of elaboration. I have chosen two mnemonic strategies that will be very useful to Charlie. The first one is the acronym strategy which involves creating a word where each letter stands for a vocab word. The second strategy is the keyword strategy which is the most helpful strategy for Charlie. This involves using visual images to make a link between a word and its meaning.

I will also use bottom up and top down processing to help Charlie transfer these words from his short term to long term memory. Bottom up processing is the process in which you associate the smaller parts of a concept to form the larger, overall concept. Top down processing is a process when you look at the larger picture or concept and break it down into smaller bits of information until you get the details. This is using what you already know to recognize patterns.

We can also deal with the large amount of vocabulary words using the technique called chunking. Chunking is grouping of bits of data in larger meaningful units. We can use chunking by implementing the theory of 7 plus or minus 2 which was theorized by Miller in 1956. This theory states that the "Magic number" is 7 + or – 2 and limits our capacity for processing information. We would only group together 5 to 9 words at a time to increase Charlie's ability to memorize and apply these words. Due to the phonological similarity effect, I would not chunk together words that sound similar because it creates more human error.

By the end of each tutoring section we hope that Charlie will be able to understand the vocabulary and apply it. Each study session we will attempt to have Charlie memorize four chunks of words with elaborate rehearsal in between. After each study session, we will quiz Charlie on the words using SAT practice tests so you can see that the strategies are working.

Section IV: Conclusion

I believe that this is a plan that you can reasonably implement with success because of its simple yet effective methods. You can also help Charlie implement these words in between stud sessions by giving him at home assessments or SAT practice tests. You can go over the words using the 7 plus or minus 2 methods we implied and then give Charlie a short break in between each chuck. This would be a better time for him to use his computer and watch television so his attention is not divided. When he comes back from his break you can rehearse what he just learned.

My plan is based off of the cognitive learning theory which emphasizes the relationship between the individual and their perception of the environment. Since Charlie will have an environment where his attention can be focused, where words are easy to chunk, and easy to

remember. He will be easily be able to learn his 500 SAT words if you were to hire me as his tutor.

Appendix L:

Manente Educational Psychology SPR2013

Problem I Comprehension Assessment

Date:_____

Student Name:_____

Instructions: Answer the following question to the best of your ability without the use of any outside sources. This assessment should be completed individually.

1: Describe behavioral learning theory. Identify, define, and explain as many specific concepts related to this perspective as possible and discuss how they might influence the acquisition of knowledge.

Manente Educational Psychology SPR2013

Problem II Comprehension Assessment

Date:_____

Student Name:_____

Instructions: Answer the following question to the best of your ability without the use of any outside sources. This assessment should be completed individually.

1: Describe cognitive theories of learning. Identify, define, and explain as many specific concepts related to this perspective as possible and discuss how they might influence the acquisition of knowledge.

Manente Educational Psychology SPR2013

Problem III Comprehension Assessment

Date:_____

Student Name:_____

Instructions: Answer the following question to the best of your ability without the use of any outside sources. This assessment should be completed individually.

1: Describe social constructivist theories of learning. Identify, define, and explain as many specific concepts related to this perspective as possible and discuss how they might influence the acquisition of knowledge.

Appendix M:

Manente Ed Psych Spring 2013

Final Examination Problem

In Pembleton School District, in a diverse urban elementary school, test scores have been falling for the last few years. One group of parents thinks that their children are just not being tested enough and appropriately rewarded for their performance. A second group argues that the students need to go back to basics and focus on knowledge, whereas another group argues that their children really need to learn problem-solving skills. You have been hired as an educational consultant to advise the school board about which approach to use especially concerning instruction related to the school's math curriculum. Pembleton is an Abbott School District. Consistent with the Abbott decision, a new instructional approach, one that has evidence for its effectiveness, must be adopted.

Use this information and the following descriptions of the three parent perspectives to prepare a 3-5 page report for the school board that lays out the evidence about, and implications of each of these viewpoints. Be sure that your report provides clear guidelines related to your recommendations for curriculum reform. The board will need this information in one week from now in order to make their decision and be able to explain it to the parents.

One group of parents, led by Ms. Brooks and Mr. McPeck complain that their students are just not motivated to learn. They argue that students need to know that there are consequences for their actions and suggest that students need to understand the rewards and punishments for hard work. As evidence for their position, they bring in the following magazine clipping:

> Learning is merely the acquisition of learned behaviors and all behaviors are ultimately initiated by the external environment. Instruction must transmit skills to the students. Learning thus involves a linear acquisition of very specific skills in a sequence from simple to complex. To help students progress, they should be tested frequently and be reinforced for their progress.

Manente Ed Psych Spring 2013

A second group of parents led by Mr. Day and Ms. Jeong disagree with the first group and argue that what students need to focus on is acquiring knowledge in order to become culturally literate citizens. The Day-Jeong group wants to focus on basic literacy and important knowledge. They suggest that whole-class instruction followed by objective testing is the most efficient way to assure that students learn these facts. They cite the argument made in another magazine article that claims:

> Research findings show that literacy and learning depend on shared background knowledge. This can be achieved by a national core curriculum. Such a curriculum would emphasize knowledge of a wide range of subjects. It is a basic axiom of learning that the quickest way to learn something new is to associate it with existing knowledge structures in long-term memory. If knowledge in memory is well organized, then we find it easy to make analogies that allow us to accommodate new information quickly. A focus on knowledge will help our students become critical thinkers. There is a technical correlation between critical thinking and literate culture because all intellectual skills depend on becoming automated. The correlation of skill with speed is explained by a fundamental limitation of short-term memory. If an intellectual operation takes more than a second or two before it can unify 5 or 6 elements, the mind forgets some of the critical components in the problem and has to start over. The only way around this bottleneck is to have one's mind well stocked with specifically relevant knowledge. This allows the mind to deal with integrated chunks instead of many isolated elements in each new problem. Thus, having the relevant background knowledge is what enables one to have intellectual skills. Knowledge is not just power, it is also speed.

Manente Ed Psych Spring 2013

The third group of parents, led by Ms. Taylor and Mr. Gold, disagree with the other two groups of parents. They argue that knowledge acquired in school does not transfer to problems encountered outside of school and that schools need to teach students to be effective problem solvers and lifelong learners. The Taylor-Gold contingent wants a focus on learning in context, such as problem-based approaches. They back up their argument with the following newspaper clipping:

> The most important lessons of modern research on the nature of thinking are that learning is an active process and the kinds of activities traditionally associated with thinking are not limited to advanced levels of development. Instead, these activities are an intimate part of even elementary levels of reading, math, and other academic content areas. The assumption that there is a set of lower-order skills is fundamentally misleading and colors much educational theory. This has been used to justify long years of drill on the basics before thinking and problem solving are demanded. Research suggests that failure to cultivate aspects of higher-order thinking may be a major source of learning difficulties, even in elementary school. Schools should not be about handing down a set of static truths to the next generation. Students' abilities to think critically should be honored and honed. In such "thinking" classrooms, facts and skills are important but are not ends in of themselves. Rather, such classrooms are likely to be organized around broad themes connected to real issues. Classrooms should be places where communities of learners negotiate meaning as they construct knowledge by engaging in discovery and invention, reflection and problem solving. In such a community, learning focuses on higher-order thinking skills, cognitive and metacognitive strategies, and learning with understanding.

Appendix N:

Name:_____

Educational Psychology: Principles of Classroom Learning
300:306 Manente Spring 2013
Final Exam -5/10

1) Which of the following is an example of automaticity?
   A) Earl cleans up his room after school without having to be reminded by his mother.
   B) When our eyes become somewhat dry, we blink them several times rapidly.
   C) When we touch a hot stove, we draw our hand back instantly.
   D) A swimmer makes a flip turn without thinking about the individual parts of the turn.

2) Which is the best example of *top-down* processing?
   A) a student reads a passage in which every 5th word is missing, and must fill in the missing words
   B) because his students already know many history facts, a teacher presents new information by helping students reference their existing internal representations
   C) students practice how to dribble a basketball, and after mastering that skill they must dribble while running down the court
   D) the sounds associated with individual letters are identified by a learner, and combined to make a word

3) Which of the following is the best description of a theory?
   A) A set of related concepts and ideas that psychologists use to understand learning
   B) An intellectual framework that organizes knowledge about a phenomenon
   C) An idea that some people believe to be true, but that has not been fully tested
   D) Our current best idea about how things work

4) What are the characteristics of a good problem for problem-based learning?
   A) They should encourage group participation and avoid conflict.
   B) They should have no right answers, but clearly have some wrong answers.
   C) They should focus on a single, important instructional objective.
   D) They should be complex, open-ended, and ill-structured.

5) A teacher presents a series of instructions, but then finds that students tend to remember only the first thing she said, and the last. While all of these could be involved, identify the best explanation:
   A) Interference
   B) Sensory Memory
   C) Serial Position Effect
   D) Decay

6) Which of the following are NOT one of the eight forms of intelligence described by Gardner:
   A) Linguistic
   B) Bodily-Kinesthetic
   C) Historic
   D) Naturalistic

7) By law all students with special needs must be provided with which of the following?
   A) A classroom aid or paraprofessional
   B) Full inclusion into classroom life
   C) An individual education program
   D) Specific modifications to the curriculum

8) Linus is recalling a weekend spent with a favorite uncle. He thinks back on the list of things below. Which is an example of a semantic memory?
   A) He learned how to parallel park a car.
   B) They went on a great picnic near the falls.
   C) His uncle told him about his great grandfather.
   D) He was stung by a bee.

9) Which of the following is an example of instruction which exists at Bloom's level called application?
   A) Producing a set of multiplication facts in a given amount of time.
   B) Comparing and contrasting the causes of WWI to WWII.
   C) Providing a definition of a technical term in the student's own words.
   D) Doing a titration in chemistry class with a new substance.

10) Which of the following is the best example of a variable interval schedule?
   A) Each Monday, Bill walks a different route to work.
   B) When students get three math homework assignments in a row all correct, they are excused from the next one.
   C) Judy buys a scratch off lottery ticket every week, and occasionally has a winner.
   D) Maria treats herself to a muffin whenever she exercises.

11) Chris is often not interested in what goes on around him. He does not like to interact with others and spends a lot of time sitting and rocking. He is very much interested in things related to space, but not much else. With which of the following is this set of behaviors most closely associated?
    A) Attention deficit disorder
    B) Attention deficit hyperactivity disorder
    C) Autism
    D) Mental retardation

12) Which statement about short-term memory is true?
    A) if information is directed into the short-term memory system, it can no longer enter long-term memory
    B) its capacity is unlimited
    C) without a strategy to prolong it, its duration is only three minutes
    D) none of the above are true

13) Marcus waits in line to take his driver's license test. "I can handle this, no problem," he decides. "I'm good at answering those kinds of written questions, and I've got the skills to do well on the driving course." Which term below best describes Marcus's motivational state?
    A) Self-motivation
    B) Self-efficacy
    C) Self-esteem
    D) Self-regulation

14) Which of the following is the best example of *positive interdependence*?
    A) Each student encourages other students to do their best.
    B) Janell has won the fourth grade spelling bee.
    C) Four students work together for a common grade on a science project.
    D) Mrs. Jackson compliments all of the students in the algebra class for doing well.

15) Which best describes *elaborative rehearsal*?
    A) connecting meaning to information so that it is transferred into long-term memory
    B) focusing attention very selectively so that information presented only briefly can be sensed and processed
    C) practicing a task repeatedly until it can be done without conscious thought
    D) repeating information over and over without altering it

16) What is the primary purpose of an Individualized Educational Program (IEP)?
    A) To ensure that all children have an educational plan tailored to their needs.
    B) To help regular classroom teachers effectively mainstream children into their classrooms.
    C) To provide a comprehensive plan of instruction for children with special needs.
    D) To advise teachers on how to modify assessments for children with learning difficulties.

17) The levels of Bloom's Taxonomy include:
    A) Knowledge, Evaluation, Application, Examination, Comprehension, Synthesis
    B) Synthesis, Application, Knowledge, Evaluation, Analysis, Comprehension
    C) Knowledge, Comprehension, Application, Analysis, Synthesis, Assessment
    D) None of the Above

18) A stimulus that decreases the likelihood of the occurrence of a particular response in the future is referred to as a:
    A) Reinforcement
    B) Time out
    C) Punishment
    D) Reprimand
    E) None of the above/Not enough information

19) Roger has a big test coming up in two weeks. He lays out a schedule that involves studying for the test for one hour every other day. What is this an example of?
    A) Mnemonic strategies
    B) Depth of processing
    C) Graphic organizer
    D) Distributed practice

20) The fundamental distinction between "group work" and collaboration involves:
    A) Trust
    B) Turn Taking
    C) Interdependence
    D) Engagement

21) Reinforcement of gradual approximations of a desired behavior refers to:
    A) Positive Practice
    B) Scaffolding
    C) Self Regulation
    D) Shaping

22) Which of the following statements describes cognitive theories of learning:
    A) The learner interacts with the environment and receives information from the environment through the senses
    B) Learners assume an active role in making meaning of their experience
    C) The amount of information that a learner can process is limited by the capacity of various components of memory
    D) All of the above

23) Which of the following is the most prevalent classification for students with special needs?
    A) Learning disabilities
    B) Autism and related disorders
    C) Attention deficit disorder
    D) Physical disabilities

24) Which statement best describes dialectical constructivism?
    A) Construction of new knowledge comes from inside, with the learner creating new knowledge from structures which already exist mentally within the learner.
    B) Knowledge is derived from the environment, with the learner constructing knowledge through interaction in the physical world.
    C) Learners acquire knowledge by continuous interaction with their social context, with all actions resulting in feedback that influences new actions.
    D) With each behavior the learner experiences a consequence, which either increases or decreases the likelihood of the behavior occurring again.

25) IDEA mandates publicly funded education for all students with a disability up to age 18.

    T----------F

26) Which of the following is the best description of *intrinsic motivation*?
   A) A type of achievement motivation in which one strives to be the best at whatever one does
   B) An environmentally-created reason to initiate or persist in an interaction
   C) An inherent propensity to engage in one's interests and to exercise and develop one's capacities
   D) The innate drive to seek activities which involve social interaction and give a feeling of belonging

27) The term "stereotypic behavior" as it relates to Autism refers to:
   A) Skills of auditory perception
   B) Ritualistic or repetitive movements
   C) A deficit in communication
   D) Limited interests

28) Which best describes a student in the zone of proximal development?
   A) Akiko helps others with their projects on the solar system, but never seems to get her own project done.
   B) Cassandra can usually complete a research paper without help from anybody.
   C) Joey cannot complete the algebra problem, but he can solve simpler problems that are closely related.
   D) Trey can write a hypothesis statement with help from the teacher or one of his friends.

29) There are many cognitive theories of learning that are not constructivist.

   T----------F

30) I.D.E.A. mandates that all students with disabilities receive:
   A) An affordable education
   B) An Individual Development Plan (IDP)
   C) Education in the least restrictive environment
   D) Free or reduced cost meals

31) In which of the following situations is the parent's attention to their child the best example of *positive reinforcement*?
   A) A parent smiles at their child while they are eating breakfast together
   B) A mother picks up her child every time he cries which results in the child crying more often
   C) A father tells his son that he is proud of him
   D) A mother gives her child candy to get them to stop crying in the supermarket

32) IQ is best described as:
   A) An individual's innate cognitive ability
   B) An individual's mental age divided by their chronological age multiplied by 100
   C) An exact measure of academic potential
   D) None of the above

33) Which of the following best demonstrates an application of scaffolding?
   A) Joseph is having trouble with juggling three balls. The teacher suggests that he work a little bit longer on two balls to make sure he has the technique right.
   B) Seeing some students struggle with two-digit multiplication, the teacher gives them maps to work on instead.
   C) Martin has just completed a biology dissection. The teacher compliments him on the quality of the work he has done.
   D) The teacher reviews the class homework with the class as a whole to make sure that everyone is ready to move on to the next unit.

34) Which of the following is the best example of a summative assessment?
   A) An elementary teacher asks a student to explain his reasoning on a mathematics task.
   B) A high school teacher observes students as they complete a biology laboratory.
   C) A sixth grade class takes the statewide assessment.
   D) A teacher provides feedback on a first draft of a writing assignment.

35) One of the defining characteristics of Autism is a tendency to have a special skill or "savant" ability.

   T----------F

36) Which of the following is an example of the *jigsaw* approach to peer learning?
   A) A group is learning about the solar system, with individuals in the group assigned to become experts on different planets, then teaching other students.
   B) A tutor requires deep processing from his tutee on the topic of the role of veins in the circulatory system before the tutee can move on to learn about the heart.
   C) Students are asked what they think about animal rights, pair together to discuss it, then share their conclusions with the class.
   D) Student teams are given some of the pieces of a concept they are learning, and then must use classroom resources to acquire the remaining pieces.

37) Which of the following sayings best illustrates the idea of *collective efficacy*?
   A) A stitch in time saves nine
   B) Many hands make light work
   C) Actions speak louder than words
   D) You can lead a horse to water but can't make him drink

38) Which of the following is NOT a process of self-regulated learning:
   A) Goal Setting
   B) Time Management
   C) Intrinsic Motivation
   D) Self-monitoring

39) Fiona believes that she is good at mathematics and will be able to learn what she should in the upcoming semester. But she has heard that her new teacher is a bit of a loose cannon, and she is afraid what her grade will be. What is Fiona struggling with?
   A) Personal behavior history
   B) Physiological state
   C) Mastery beliefs
   D) Calibration

40) Formative assessment refers to:
   A) Information the teacher can use to determine what students have accomplished
   B) An assessment given prior to instruction
   C) A way of assigning grades
   D) The evaluation of an instructional unit

41) Which is the best example of a keyword strategy?
   A) Maria knows that "one is a bun, two is a shoe…," so to remember that the number one cause of death in women is heart disease, she imagines a woman eating a heart on a bun.
   B) To recall the Great Lakes (Huron, Ontario, Michigan, Erie and Superior), Jordan uses the acronym: HOMES.
   C) To recall the three things he needs for gym class, Dewayne visualizes a walk to campus and imagines a towel on the sidewalk, soap dripping off the stoplight and gym shorts at the campus fountain.
   D) To remember that the Spanish word for phone booth is "cabina," Derrick imagines a taxi cab stuffed into a phone booth.

42) Which of the following is the best definition of operant conditioning?
   A) A learner performs some act, and depending upon what happens as a result, the likelihood of the learner doing the act again increases or decreases.
   B) Automatic responses in a learner become associated with new stimuli because they occur at about the same time.
   C) Learners set goals which help them understand how to operate in the environment in the most adaptive and functional way.
   D) When environmental conditions strongly resemble a previous situation, the learner has an increased likelihood of behaving in the same fashion.

43) The eugenics movement refers to an initiative for the civil rights of people with disabilities.

T----------F

44) Which is the best example of *Problem-Based Learning (PBL)*?
   A) Students discuss ideas with their teacher to reach a mutual understanding of a difficult passage from Shakespeare.
   B) Students work in cooperative groups to figure out which crops should be grown in which geographical regions.
   C) Students work individually to create math problems which they then present to others in their group to solve.
   D) Teachers assign individual students to study the topic of global warming, and then they debate with each other, defending their positions.

45) Which of the following is the best example of a formative assessment?
   A) An algebra unit test that will count for 10% of the final grade.
   B) The SATs
   C) The written test for a driver's license.
   D) A quick quiz given in the middle of a social studies unit.

46) Which of the following is the best example of an *authentic* learning task?
   A) A teacher has students learn formulae for determining the area of a rectangle and a circle.
   B) In personal finance class, students attempt to create a budget for the upcoming student dance.
   C) Students are assigned daily homework in which their parents help correct students' social studies worksheets.
   D) A teacher has students make their own mnemonic device for memorizing the states and their capitals.

47) Positive punishment is a consequence that is viewed as fair by the student, while negative punishment is seen as unfair.

T----------F

48) Which best describes the difference between self-efficacy versus mastery beliefs?
   A) Belief in your social skills versus belief in your academic skills
   B) Being able to control outcomes versus setting reasonable goals
   C) Belief in your ability versus belief in ability to control the environment
   D) Setting goals versus initiating action toward those goals

49) Mr. D'Ambosio is working on developing higher order skills with his students using a cognitive elaboration approach. Which of the following pieces of information about his students might be the most useful?
   A) Level of interest in the new topics
   B) How they respond to rewards and praise
   C) Their prior knowledge and schemas
   D) Their attitudes toward team building and social skills

50) Which of the following is the best simple definition of metacognition?
   A) Metacognition is thinking about thinking.
   B) Metacognition is philosophical thinking.
   C) Metacognition is thinking about things that are entirely new.
   D) Metacognition is thinking about the application of new ideas.

Appendix O:

IRB Attachment 7

Research Survey

Your participation in completing this survey is completely voluntary and your responses will be kept anonymous. By filling out this survey you are giving permission that your responses may be used for research.

Title of Study: Is Collaboration a Necessary Component of Problem-based Learning?
Principal Investigator: Christopher J. Manente
Academic Advisor: Dr. Angela O'Donnell

1. Did you prefer any of the instructional designs you encountered throughout your Educational Psychology course over all others?

2. Did you prefer to work in a group or independently?

3. Was there any instructional design that encouraged your learning more than the others?

4. Does your opinion of collaborative learning designs differ after taking this course from before you encountered the course material?

5. Do you feel that there were benefits associated with participating in the various problem-based learning instructional designs beyond your acquisition of factual/content knowledge? If so, please describe some of the other benefits.

6. Would you consider using any of the variations of Problem-based learning that you encountered throughout the course in your own classroom?

Appendix P:

IRB Attachment 4

Consent Form to Participate in a Research Study

Title of Study: Is Collaboration a Necessary Component of Problem-based Learning?
Principal Investigator: Christopher J. Manente
Academic Advisor: Dr. Angela O'Donnell

INTRODUCTION

You are invited to participate in a research study. Before you agree to participate in this study, you should know enough about it to make an informed decision. If you have any questions, you should ask the investigator or his academic advisor. You should be satisfied with the answers before you agree to be in the study. This study will be conducted within the context of your Educational Psychology course throughout the current semester.

BACKGROUND/PURPOSE

Instructional techniques that utilize collaborative problem solving among students have become very popular in numerous educational settings. These instructional designs often utilize "cases" or hypothetical summaries of practical situations, to present the initial problem to student teams. The primary purpose of this study is to determine whether there is a difference in student performance resulting from instructional designs involving group work or from those that require students to work independently. The study will also attempt to identify the conditions that contribute to successful collaborative groups.

INFORMATION

Three variations of problem-based learning (PBL) will be used to provide instruction on three of the primary course topics. The PBL variations will include a collaborative format, a group-work format, and an independent format. In the collaborative and group-work formats students will work in teams to develop solutions to a number of problems presented in case form. In the independent format students will work alone to develop solutions to a number of problems presented in case form. Students will be required to submit a formal problem solution and take an examination meant to assess their comprehension and application of course content following each variation of PBL. Student performance on examinations following each instructional format will be compared in order to identify any differences that exist. This study will take place within the context of the Educational Psychology course for which you are currently registered. The part of the course that will be of particular interest to the results of the research study will occur during six course meetings spread throughout the semester for a total of 18 total hours of instruction. At the end of the course, participants in the study will be asked to complete a questionnaire related to their preferences for each of the three forms of PBL instruction. Completion of the questionnaire will be voluntary and all responses will be kept anonymous.

I acknowledge that I have read and understand the information presented on this page. Subject Initials: _____

IRB Attachment 4

ALTERNATIVES TO PARTICIPATION

Participation in this study is voluntary and any student enrolled in the section of Educational Psychology where the research will occur has the right to opt out of having their performance on examinations used for the purpose of research. If you do not wish to participate in the study you have two alternate options: 1. You could simply opt out of participating in the study and remain in the section of the course where the research will be conducted. If you select this option, you will still be required to participate within the requirements of the various instructional designs for the purpose of learning required course content. However, your performance in the course would not be used for the purposes of research. 2. You could withdraw from the section of the course where the research is being conducted and enroll in one of the several other sections of Educational Psychology.

RISKS

Because the primary investigator of the study will also be the instructor for the course there is some risk of students feeling pressured to participate in the research. There is also a risk that student performance specific to the research design could have an effect on the instructor's ability to assign grades fairly for the course.

These risks will be addressed by the instructor/research investigator being unaware of the identities of the students that choose to participate or opt out of participating in the research study. If you choose to participate in the study, the data related to your performance in the various conditions will be linked to a number which has no relation to your identity by a researcher other than your course instructor before the results are examined. Additionally, data analysis for the study will not begin until after final grades for the course have been officially submitted to the registrar.

BENEFITS

Participation in this study may not benefit you directly. However, the knowledge that we obtain from your participation, and the participation of other volunteers, may help us to better understand which types of instruction represent "best practices" for students across grades and settings.

CONFIDENTIALITY

This research is confidential. The research records will include some information about you and this information will be stored in such a manner that some linkage between your identity and the response in the research exists. Some of the information collected about you includes your gender, academic major, and state of progress towards graduation. Please note that we will keep this information confidential by limiting individual's access to the research data and keeping it in a secure location. In addition, we will ensure that all links between your identity and the data related to your performance will be removed immediately following the academic semester.

I acknowledge that I have read and understand the information presented on this page. Subject Initials: _____

IRB Attachment 4

The research team and the Institutional Review Board at Rutgers University are the only parties that will be allowed to see the data, except as may be required by law. If a report of this study is published, or the results are presented at a professional conference, only group results will be stated. All study data will be kept for five years after final publication of the research. It will be maintained under lock and key until such a time.

COMPENSATION

There will be no form of compensation offered for your participation in this study.

CONTACT

If you have questions at any time about the research or the procedures, you may contact the researcher, Christopher J. Manente, at 151 Ryders Lane, New Brunswick, NJ 08901 or by phone or email at 732-668-7260, or christopher.manente@rutgers.edu. You may also contact the researcher's academic advisor, Dr. Angela O'Donnell in the Department of Educational Psychology at the Graduate School of Education at 732-932-7496 ext.8317. If you have any questions about your rights as a research subject, you may contact the IRB Administrator at:

Rutgers University Institutional Review Board for the Protection of Human Subjects
Office of Research and Sponsored Programs
3 Rutgers Plaza
New Brunswick, NJ 08901-8559
Tel: (848) 932-0150
Email: humansubjects@orsp.rutgers.edu

PARTICIPATION

Your participation in this study is voluntary; you may decline to participate at any time without penalty to you. If you decide to participate, you may withdraw from the study at any time without penalty and without loss of benefits to which you are otherwise entitled. If you withdraw from the study before data collection is completed your data will be removed from the data set and destroyed.

Sign below if you agree to participate in this research study. You will be given a copy of this form to keep.

Subject's Name (please print)_____ Date _____

Subject's signature_____ Date _____

Investigator's signature_____ Date _____

I acknowledge that I have read and understand the information presented on this page. Subject Initials: _____

APPROVE
MAY 09 201
Approved by the Rutgers IRB
EXPIRES
MAY 08 2014
Approved by the Rutgers IRB
3

IRB Attachment 4

Consent Form to be Videotaped for the Purpose of a Research Study

RATIONALE

You have been invited to participate in a research study entitled "Is Collaboration a Necessary Component of Problem-based Learning," that is being conducted by Christopher Manente, an adjunct professor and doctoral student at Rutgers University. The primary methods of data collection for this research will be conducted via written assessment. However, a video record of your participation during group work in the course may be beneficial in addressing the objectives of the study. If you choose to allow your performance during group tasks to be recorded the data will be kept confidential in that your name and other forms of information related to your identity will not be linked to the video. The data will also be kept in a secure location and will not be accessible to anyone other than members of the research team and the Institutional Review Board at Rutgers University. If you choose not to be recorded for the purpose of this study you will be assigned to a collaborative group whose discussions will not be audio/video recorded. Even if you choose not to be videotaped you will still be eligible to participate in all other aspects of the study and will also still be expected to fulfill the core requirements associated with the course.

PLEASE INITIAL BY THE APPROPRIATE CHOICE

I **DO NOT** provide consent to videotaped as a part of the research study _____

I **DO** provide consent to be videotaped as a part of the research study _____

_____I **DO NOT** provide consent for segments of the recordings made of my participation in this research to be used for conference presentations.
_____I **DO** provide consent for segments of the recordings made of my participation in this research to be used for conference presentations.

_____I **DO NOT** provide consent for segments of the recordings made of my participation in this research to be used for the education and training of future researchers/practitioners.
_____I **DO** provide consent for segments of the recordings made of my participation in this research to be used for the education and training of future researchers/practitioners.

_____ _____
Participant's Name (please print) Date

_____ APPROVED EXPIRES
Participant's signature MAY 09 2013 MAY 08 2014
Approved by the Rutgers IRB Approved by the Rutgers IRB

Investigator's signature: _____ Date: _____

I acknowledge that I have read and understand the information presented on this page. Subject Initials: _____ 4