DO CONCEPT-MAPS SERVE AS AN APPROPRIATE SCAFFOLD FOR PROBLEM-BASED LEARNING ENVIRONMENTS?

By

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Abstract

Collaborative learning designs, such as problem-based learning (PBL), have the potential to help students build valuable team-based professional skills needed for life after schooling within higher-educational settings (Desimone, 2009; Savery, 2006); however, motivating students to work together to successfully achieve outcomes often proves challenging. Research has shown that high-quality socially shared regulation (SSR) can improve these outcomes, but research is limited in determining the best instructional practices, and scaffolds, for fostering interdependence and sustained collaboration. The purpose of this study was to use Belland, Kim, and Hannafin's (2013) framework for designing scaffolds, that aims to improve on motivation and cognition, to extend previous research conducted by Manente (2014) and Rogat & Linnenbrink-Garcia (2011; 2013), and determine whether incorporating concept maps into PBL tasks would improve student performance and increase the frequency and quality of SSR. This mixed methods study took place within an educational psychology course at a large university. Participants were 16 undergraduate sophomore and graduate students who were divided into 4 groups, trained in the use of concept maps, and then engaged in three PBL conditions during the semester—PBL-Independent, PBL-Positive Interdependence, and PBL-High Positive Interdependence. Quantitative analyses of student scores on problem solutions and comprehension assessment scores showed students had the highest scores in the PBL-High Positive Interdependence condition. This study showed that the addition of concept maps contributed to the improvement of student scores on comprehension assessments, by comparing students' performance with students' performance on comprehension assessments from Manente's (2014) study. Qualitative analysis of group interactions showed that groups exhibited high quality SSR during the PBL-High Positive Interdependence condition, and processes of task planning, content planning and content monitoring were the most frequently used across groups. Overall, findings supported the use of concept maps as a tool to increase the effectiveness of PBL and students SSR and effective group skills. Areas of future exploration were also identified, including but not limited to, examining the degree to which concept maps impact cognitive load, and determining ways to effectively and gradually fade out hard scaffolds in order to promote independence.

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Introduction

To many, the goal of gaining a college education is to be able to consolidate several years of learning into marketable and job-ready skills, and graduate, prepared to enter the workforce and pursue a career. However, college instructors are continually faced with the challenge of teaching their students how to link the theories taught in classes to practices that can be generalized to the "real world." One of the theories that has been proposed, in more recent years, to help in this process is student-centered learning, or the practice of allowing learners to not only choose what to study, but how and why the topic may be of interest to them (Rogers, 1983). Often student-centered learning environments require students work together in small groups (Wright, 2011). Unfortunately, though research has demonstrated that teachers are often student-centered in philosophy, they are frequently teacher-centered in actual approach (Becker, 2000; Major & Palmer, 2001; Wright, 2011). In teacher-centered classrooms, the teacher is an information provider (e.g. lecturer) or evaluator who monitors student's right and wrong answers, rather than insuring students have understanding of concepts, their relationships and how the information students learn can transfer as in student-centered classrooms (Wright, 2011). Despite empirical evidence of the importance of student-centered instructional practices that incorporate student collaboration within undergraduate classrooms, many programs fail to develop and implement evidence–based teaching practices that truly help foster students' professional development (Desimone, 2009; Savery, 2006).

One frequently under-taught professional skill is the ability to work effectively in collaboration with others (Desimone, 2009). This is often considered an invaluable skill given the need to work on teams with colleagues and coworkers in many professions. Incorporating collaborative learning designs into higher-education settings is one student-centered strategy that has been used to help build this skill for students (Desimone, 2009; Major & Palmer, 2001). One way of creating collaborative learning environments is through the use of problem-based learning (PBL). In PBL students are presented with an ill-structured problem and they are required to gather information and apply knowledge and skills from multiple disciplines and sources as they assess an array of plausible solutions (Torp & Sage, 2002). Ideally, this approach works to elevate a student's intrinsic motivation to learn more about a topic or subject, and can also serve as a way for students to develop cross-cultural understanding by working as a team to solve a problem (Barrows & Tamblyn, 1980; Performance-based assessment, 2008; Savery, 2006).

However, though PBL and collaborative learning have the potential to help students build highly relevant professional skills, achieving successful coordination between group members is not always an easy process (Desimone, 2009; Hmelo-Silver, 2004; Savery, 2006). Part of the reason for this is that each group member is a self-regulating agent with unique goals, cognitions, emotions, and challenges related to their motivation toward the assigned task. For example, students may face difficulties finding common ground in shared problem solving, or struggle with negotiating multiple perspectives when handling complex concepts (Järvelä, Volet & Jarvenoja, 2010). A lack of individual accountability within a group can also give rise to undesirable outcomes, such as off-task behavior, irrelevant socialization, disengagement, lack of effort, or ineffective argumentation (Chinn, Buckland, & Samarapungayan, 2011; Gillies & Boyle, 2010). Therefore, it is important for instructors to implement practices that can help students effectively manage their experiences and learning both individually and within groups.

Research has demonstrated that successful collaboration requires self-regulation, as well as socially shared regulation (SSR) (Järvelä & Hadwin, 2013; Vauras, Iiskala, Kajamies, Kinnunen, & Lehtinen, 2003). Self-regulation has been found to consist of three main components or behaviors—planning, or the way in which groups set task-specific goals; monitoring, or the way in which groups understand the process during their joint work on a task; and behavioral engagement, or the way in which groups eliminate distractions and encourage group members to participate in the task throughout the problem-solving process. Rather than focusing on these processes solely at an individual level, SSR looks at the "contextualized nature of students' experiences during group work" (Rogat & Linnenbrink-Garcia, 2011, p.377), and refers to the ways in which individuals and groups use these processes and sub-processes to regulate their joint work on a task (Rogat & Linnenbrink-Garcia, 2011; Vauras et al., 2003). In other words, if an individual is self-regulated they can effectively plan, set goals, organize their thoughts, self-monitor their work, self-evaluate their work, and progress through a learning task. Rogat and Linnenbrink-Garcia (2011) examined whether the self-regulatory processes for individuals—planning, monitoring, and behavioral engagement—could be applied to socially shared regulatory episodes in a group context. Socially shared regulation refers to the social processes group members use to regulate their joint work on a task, or "regulation in unison" (Winne, Hadwin, & Perry, 2013, p.46). When studying socially shared regulation, researchers focus on a group's co-construction of plans, monitoring strategies, behavioral engagement, interactions, and negotiations of meaning. Rogat and Linnenbrink-Garcia (2011) found that a higher or lower ability to plan, monitor, and behaviorally engage was associated with positive or negative group regulation, respectively.

Collaboration is an important component of SSR, because when group members work collaboratively they encourage each other to ask questions, articulate their thoughts, justify and negotiate their opinions, elaborate their knowledge, co-construct meaning, and work toward a shared understanding of the task (Vauras et al., 2003; Webb, 1995). If group members did not collaborate then they would not be exhibiting SSR. For example, a group that does not collaborate might compartmentalize tasks, or complete tasks individually without sharing the information and understanding with their group members. With that said, the degree to which individuals' collaborative effort varies can influence the quality of SSR exhibited by the group (Brown & Palinscar, 1989; Rogat & Linndenbrink-Garcia, 2011). Placing students in a group does not guarantee that they will interact in way that fosters understanding and benefits learning (Webb & Palinscar, 1996). Research investigating group processes suggests that students need to be explicitly taught how to sustain collaboration, and that, when successful, sustained collaboration supports student learning during small group activities (Roschelle & Teasley, 1995; Slavin, 1990; Webb, Kersting, & Nemer, 2006). Other researchers have suggested that designs that foster positive interdependence, or group members relying on one another and working together to achieve a goal, are also linked to positive group-work outcomes, high-quality SSR, and successful collaborative learning (Rogat & Linnenbrink-Garcia, 2011). Implications from Rogat and Linnenbrink-Garcia (2011) specifically state, "to support social regulation, an intervention could be designed that builds on extant group programs for strategies to foster interdependence and sustained collaboration (Johnson & Johnson, 1991; Slavin, 1995) and high quality social interactions (Cohen, 1994)" (Rogat & Linnenbrink-Garcia, 2011, p. 411). Though determining which instructional designs can successfully foster positive interdependence can be challenging, it is important for researchers to further investigate how to design a learning environment that supports powerful small group work (Rogat & Linnenbrink-Garcia, 2011).

Positive interdependence can be promoted through resource interdependence, where group members must share task resources; or reward interdependence, where group members must act together to gain a group reward; or some combination of the two (Johnson & Johnson, 2002). One strategy often used to help foster positive interdependence in PBL and group learning is the incorporation of concept maps (Daley & Torre, 2010). Concept mapping is a technique that allows students to solve problems creatively by visualizing prior knowledge, organizing concepts, and integrating new knowledge in order to separate what is already known from what needs to be further researched (Novak, 2010; Rye, Landenberger, & Warner, 2013; Zwaal & Otting, 2012). Concept maps have not only been shown to motivate students to learn, but also to enhance their critical thinking and problem solving skills (Daley & Torre, 2010). Additionally, concept maps can elicit more extensive discussions, and allow learners to establish shared task representations and goals—two important factors that foster high-quality SSR and successful group processes (Hay, Kinchin & Lygo-Baker, 2008; Novak, 2010; Rogat & Linnenbrink-Garcia, 2011).

Research has demonstrated that integrating concept mapping and web-based problem solving tasks not only engages students in higher-order thinking and challenging tasks, but also increases the complexity of the learning content in comparison to individuals who did not use a concept map (Hwang, Kuo, Chen, & How, 2014). Additionally, studies of healthcare professionals suggest that concept mapping can provide a clear representation of students' knowledge structures, allowing instructors to more easily evaluate students' progress, identify areas of improvement, and provide feedback and support to help correct student misconceptions (Hung & Lin, 2015). One challenge to the successful implementation of concept maps in student-centered learning environments is students' lack of familiarity with working in this way. Scaffolding, or reducing the cognitive load of an activity by structuring the problem-solving process, is one way to address this as instructors can use it to enhance opportunities for learning and understanding in group work (Hmelo-Silver, Duncan, & Chinn, 2007)

Scaffolding is a dynamic system of support, and requires the instructor to be responsive, sensitive, and flexible in order to combine students' established skills with opportunities for growth. Finding a balance can be challenging as instructors often provide too little or too much assistance, block independent exploration, or provide scaffolding techniques in untimely manners. Concept maps can serve as a learning strategy that offers benefits to the student and can be used by the instructor as a guide for providing appropriate, timely scaffolding support when managing numerous small collaborative groups during PBL. Though research has shown the benefits of concept maps in fostering learning in general, there has been limited research directly exploring the use of concept maps within PBL environments, or their impact on group learning and socially shared regulation specifically. Thus, further investigation is warranted, especially given the challenges instructors face in helping students gain such an important real-world skill.

Research Questions

This study used a mixed-methods design to explore the following research questions:

1) Do concept maps serve as an adequate structure to scaffold student development of skills related PBL?
    a) Does the use of concept maps effect individual and group task and assessment performance? To what degree do concept maps affect individual test performance and group task performance?
    b)) Do conceptual gains produced on a concept map associated with change in performance outcomes on problem solutions, comprehension assessments, and finals?
2) What PBL instructional designs provide opportunities for students to engage in SSR?
    a) What kind of SSR processes are exhibited by students working on PBL activities?

3) To what degree do concept maps affect the quality of SSR exhibited within small group work?
   a) Are students engaging in high-quality SSR when using concept maps as a tool to solve problems?
   b) What student-centered PBL instructional designs provide for students to engage in high quality SSR when using concept maps as a tool?
   c) How does "team evaluation" foster a higher level of interdependence and sustained collaboration, which supports high quality social regulation?

In order to answer these questions, this paper will 1) present a general literature review on the theoretical foundations of collaboration, socially shared regulation, instructional supports and scaffolds that can support learners in group in PBL. 2) present the rationale and methods for the current study design, 3) Provide the results of the quantitative and qualitative analyses conducted, 4) Discuss the implications of the data for the research questions, and 5) Conclude with recommendations for further research.

Literature Review

In order to understand the best practices to support socially shared regulated learning, I explored literature related to theoretical underpinnings of collaborative learning environments and reviewed literature associated with group regulatory processes. The second body of literature discusses the instructional design of PBL. Then I concluded by discussing the instructional strategies and scaffolds that have been used to support learners in collaborative learning environments.

Theoretical Framework

Two theoretical frameworks inform this dissertation—1) theories of collaboration and 2) theories of scaffolding and learning strategies. Theories of collaboration have been used to explain how individual self-regulatory strategies influence group processes, and how group regulatory processes impact collaborative learning outcomes (Barron, 2000; Dillenbourg, 1999; Rogat & Linnenbrink-Garcia, 2011). This body of research serves as an important foundation for this study because it provides insight into how learners can effectively work together in groups. The second body of research focuses on the use of scaffolding and learning strategies to support learners who are faced with a complex problem, with many studies focusing on determining appropriate ways to support collaborative learning environments (Belland, et al, 2013; Quintana et al., 2004). Identifying the appropriate instructional design, scaffolding techniques, and learning strategies to support collaborative learning contexts is necessary, not only for the purpose of effective study design, but also because these resources serve as tools that learners can continue to use throughout their educations and futures.

Collaborative Learning

Multiple theoretical lenses have been used to explore collaborative learning, and to identify the best collaborative learning practices in the classroom setting. Education researchers tend to view collaborative learning as a social structure in which two or more individuals share goals and understanding when solving a problem (Roschelle & Teasley, 1995). If designed and executed appropriately, collaborative learning designs provide rich learning environments (Dillenbourg, Baker, Blaye, & O'Malley, 1996; Chinn et al., 2011). There are a variety of group learning contexts, and it can be beneficial for researchers and instructors to distinguish between them to in order to determine the most appropriate collaborative learning practice for their needs. Research, focused on identifying these unique collaborative contexts, has identified peer tutoring, cooperative learning, and peer collaboration as primary contexts. Peer-tutoring describes the ways in which one student supports a fellow student with the learning process (Ashman & Gillies, 2013). In cooperative learning students may share goals and task products, but have different knowledge bases and individualized goals based on their role or prior knowledge. For example, cooperative learning could be a situation in which a tutor and a student are working together to solve a problem, but the tutor already has knowledge of the topic and is guiding the student. In this situation, the pair is working together to solve the problem but they each have different tasks based on their roles. Cooperative learning involves students sharing goals and task understanding in order to build further knowledge for their own and each other's learning (Johnson & Johnson, 1989, 1999, 2005; Johnson, Johnson, & Smith, 2006). Cooperative learning can also take place when group members have similar, though not identical, roles, even if individuals still come from different knowledge bases. In this case, members learn by dividing the task into smaller sections, having each member work independently on a section, and then contributing their completed findings to the collective group product (Dillenbourg, 1999). Again, the group has a shared goal of completing the task, but members' roles are different, but somewhat equivalent, and they each may have separate goals that are not shared by the larger group. In contrast, peer collaboration involves students entering a learning context with equal knowledge, and putting in equal effort to solve the task or devise a solution to a problem. Rochelle and Teasley (1995) define collaboration as:

> …the process by which individuals negotiate and share meanings relevant to the problem-solving task at hand. Collaboration is a coordinated, synchronous activity that is the result of continued attempts to construct and maintain a shared conception of a problem (p.70).

While both cooperative and collaborative learning environments consist of individuals who participate in a group, those involved in collaborative contexts engage in activities that are for the group as a whole. Individuals in collaborative learning environments equally contribute to shared tasks that are created by the group for the group, and engage in interactions such as negotiation and sharing when completing these tasks. The collaborative negotiation and social sharing of group meetings include the development and maintenance of shared conceptions of tasks which are accomplished interactively within the group. Therefore, while individuals do learn individually in collaborative settings, their learning is also fundamentally interconnected with, and dependent on, the learning of their group members. This differs significantly from the solely individual learning that takes place in cooperative settings.

Peer-mediated designs, such as peer collaboration, allow students to exchange ideas, explore concepts, and develop new solutions in order to facilitate knowledge together. This process has been linked to cognitive conflict, or the experience that occurs when students within peer supported environments access different points of view and are forced to negotiate multiple perspectives when learning (Ashman & Gilles, 2013). Recently, researchers have explored the idea of cognitive conflict as it relates to collaborative argumentation, or the process by which two or more people engage in conversation which provides them opportunities to share evidence to support their claims about a particular concept and ultimately develop new knowledge (Chinn & Clark, 2013; Hmelo-Silver, Chinn, Chan, & O'Donnell, 2013). Researchers have found that, when students have interactions in which they are faced with ideas or beliefs that are not congruent with their own, they are required to resolve these inconsistencies and consider others' perspectives. Additionally, in order to resolve the cognitive conflict, students must explain their thinking processes, reflect, and possibly change their perspectives in order to develop new views and gain new knowledge (Ashman & Gillies, 2013; Hmelo-Silver et al., 2013). Thus, of the group learning contexts, collaborative learning environments have been demonstrated to be the most effective for promoting peer engagement, developing skills for communication and understanding, and fostering deeper learning.

Group Regulatory Processes

Anecdotally, group work is often considered one of the most challenging experiences for students and individuals in the workforce, alike. One reason for this difficulty is the fact that each member of a group is engaged in self-regulation, or a self-directed process by which an individual generates their "thoughts, feelings, and behaviors that are oriented to attaining goals" (Zimmerman, 2002, p. 65), which can make working with others a challenging endeavor. However, despite the challenges it can present, there is evidence that, when properly educated, individuals can use self-regulation strategies to benefit groups. SRL is the specific process through which a student would appropriately use component skills associated with self-regulation to accomplish a goal. These component skills can include: goal setting, a planned strategy, performance monitoring, organizing and reorganizing the social context to make it conducive to attaining the goals, monitoring time usage, attributing causation to results, and the ongoing self-improvement of learning methods (Zimmerman, 2002). It is important to note that not only is the appropriate use of the component skills necessary, but self-regulated learners must be active participants and may seek out the assistance of someone else in order to accomplish their goals. Researchers have determined that a student’s level of learning is associated with the degree to which they use these component skills of SRL and whether or not they use them at all (Zimmerman, 2002). They have also found that these skills can be learned both from direct instruction and by observing the modeling of others (Zimmerman, 2002). This research on SRL has provided educators, policy makers, and researchers with evidence that it is important to incorporate SRL into school practices and professional development models (Boekaerts & Corno, 2005; Butler, Lauscher, Jarvis-Selinger & Beckingham, 2004), because self-regulated learners are more “likely to succeed academically and view their futures optimistically” (Zimmerman, 2002, p. 65). Teaching skills of self-regulation (e.g., motivation, goal setting, self-monitoring, strategy use, self-evaluation, and metacognitive decision making) to students is important because these skills are necessary for life after school as well.

Though everyone possesses some degree of self-regulation, the literature has consistently shown that individuals who are more self-regulated emerge as more meta-cognitively, motivationally, and behaviorally active in their own learning (Zimmerman & Martinez-Pons, 1986). Learners who exhibit metacognitive processes plan, set goals, organize, self-monitor, and self-evaluate at various points during the process of knowledge acquisition (Pintrich, 2000). Learners who exhibit motivational processes have been found to possess efficacy, selfattributions, and intrinsic task interest (Schunk, 1986; Zimmerman, 1985). In their behavioral processes, self-regulated learners select, structure, and create environments that optimize learning; seek out advice; and seek out information in places where they are most likely to learn (Schunk & Zimmerman, 2008; Zimmerman & Martinez-Pons, 1986).

Though SRL is an internal process, it can also be influenced by social interaction (Zimmerman, 1990). Therefore, while much research on self-regulation focuses on the individual, some researchers have begun to examine the contextualized nature of students' experiences during group work (Zimmerman, 1990). *Interpersonal regulation*, a term coined by Vauras and Volet (2013), has been used to capture the wide range of theoretical perspectives used to describe situations groups may experience when functioning during social interaction. Most of the research on interpersonal regulation of learning has been heavily influenced by Greeno's (2006) situated learning framework, which focuses on learning that is situated in an authentic context. Others consider Vygotsky's (1978) sociocultural learning theory, which focuses how society impacts the process of individual development and an individual's acquisition of knowledge, to be heavily influenced by social and cultural interaction. These theories have become the foundation for research into complex, self-regulated systems as they relate to the study of interpersonal regulation in learning, particularly in collaborative contexts with both synchronous or asynchronous group interactions.

Concepts such as co-regulation have also been used to explain the ways in which self-regulation develops within group contexts. According to McCaslin (2009), the concept of co-regulated learning is grounded in Vygotsky's (1978) and Wertsch and Stone's (1985) ideas that co-regulation is internalized through social interaction. Typically, co-regulation involves a student and another individual with more knowledge (e.g., an advanced student or peer tutor) who helps to influence the process through which the student learns. During co-regulation participants alternate between assuming expert roles and novice roles as they complete a variety of shared tasks. Through observation and interaction, individuals in the novice role learn to engage in and control their own self-regulatory strategies, evaluations, and process. For example, Vauras and colleagues' studies on socially shared co-regulation provide evidence that when teacher scaffolding emphasizes collaborative learning and opportunities for co-regulation it provides an appropriate context for students to learn and deploy regulatory strategies (Salonen, Vauras, & Efklides, 2005; Vauras et al., 2003). Thus, this body of research points to the social context as one of the developmental sources of self-regulation.

Recent research has also investigated both individual and the group coordination of behavior, learning, and understanding during a shared activity/task. Volet, Vauras and Salonen (2009) highlighted the term *other-regulation*, which is grounded in Vygotsky's (1978) concept of the Zone of Proximal Development. The zone of proximal development explains how a learner gains understanding and works through a problem with aid from a supportive context or a more knowledgeable other, also referred to as an expert (Hogan & Tudge, 1999; Rogoff & Wertsch, 1984). More specifically, Volet, Vauras, et al. (2009) used this theory to explain the process of scaffolding by which individuals can learn and move from being other-regulated, where their performance is regulated by another individual, to self-regulated where individuals take responsibility for their own performance. There is empirical evidence that supports the differentiation between individual, other, and shared forms of regulation during group interactions; as well as the value of concurrent use of these types of regulation to maintain group work when members are confronted with a challenge (Vauras, et al., 2003). Vauras et al. (2003) suggest that like individual regulation, social regulation can also range from other-regulation, in which one person takes a more predominate role to guide the group's interactions and regulates the entire group's work on an activity, to socially shared regulation, in which group members engage in social processes to regulate their collaborative contribution to solving a shared task (Rogat & Linnenbrink-Garcia, 2011).

Socially shared regulation (SSR) refers to the social processes that groups use to regulate their joint work on a task (Vauras et al., 2003; Volet, Vauras, et al., 2009). Research on socially shared regulated learning (SSRL) focuses on the group, and places emphasis on the collective interaction and collaboration of the group as a whole (Hadwin & Oshige, 2011). More specifically, researchers assert that when groups co-construct plans and perceptions to establish a shared evaluation of progress they are engaging in shared regulation (Järvelä, Järvenoja, Malmberg, & Hadwin, 2013). Thus, socially shared regulation is examined in a group of self-regulators, and individual regulation is always studied in relation to others and to the group regulation. From this view, socially shared regulated learning means examining a collective process within a group's interaction and negotiations of meaning. Ultimately, SSRL involves independent or collectively shared regulatory processes, and acquisition strategies combined for the purpose of creating a co-constructed or shared outcome (Winne, Hadwin, & Perry, 2013; Järvelä & Hadwin, 2013).

Socially shared metacognitive regulation, or when task awareness is aligned by group members in order to co-construct a common task space for a problem, is another component of SSR that researchers have studied (Hadwin, Oshige, Gress, & Winne, 2010; Iiskala, Vauras, Lehtinen, & Salonen, 2011). Metacogntive processes are the processes of SSRL that relate to the way the group plans, monitors, implements, and evaluates its work. Individual metacognitive processes are important because they enable students to be self-aware, knowledgeable, and deliberate in their approach to learning, so that they can monitor their plans and goals (Schunk, 1985; Zimmerman, 1985). Metacognitive processes that are executed by the group are important because they enable the members to be aware, knowledgeable, and deliberate in their approach to learning, so that they can work in collaboration with one another to establish and monitor their group's plans and goals (Lee, O'Donnell, & Rogat, 2014; Rogat & Linnenbrink-Garcia, 2011). Metacognition researchers have acknowledged the role of peers and more knowledgeable others in mediating and sharing metacognitive knowledge (Brown, 1987; Goos, Galbraith, & Renshaw, 2002). These studies have focused on how group members monitor and control each other's actions to advance the group's problem solving. Teachers can foster this by encouraging group members to share responsibility, and by providing opportunities for the groups to plan, monitor, and evaluate their work (Järvelä & Hadwin, 2013). When teachers provide opportunities for groups to engage in these processes, they should highlight and reinforce processes that not only lead to the final outcome but also promote the collaboration and motivation required to complete the task (Panadero, Järvelä, & Kirschner, 2015). SSRL embraces the cognitive and metacognitive aspects of group work, and by acknowledging this offers a more complete picture of the regulation taking place at the group level.

Quality of Socially Shared Regulation

While just about all groups demonstrate SSR to some degree, groups vary in the quality of SSR that they demonstrate (e.g., other-regulation, low-content processing, and high-content processing). Research on quality variation stemmed from an investigation into the quality of co-regulation (Volet & Mansfield, 2006). Researchers in this study conceptualized quality by focusing on dimensions of social regulation ranging from high-level to low-level content processing, or the degree to which members within a group elaborated, interpreted, questioned, or explained ideas in their own words to increase understanding. Using these dimensions, Volet, Summers, and Thurman (2009) characterized the highest quality social regulation as using both shared and deep-level content processing (e.g., critical analysis, evaluation, and the application of learning content). A clear distinction can be made between high and lower quality social regulation because high quality SSR involves multiple students concurrently engaging in questioning and developing a shared understanding of the context or content. This level of group engagement allows each group member to bring relevant background knowledge to the collective group. Additionally, the previous knowledge of each group member can be elaborated upon through joint monitoring of each of the contributions brought forth by other members. In contrast, low-level regulation only involves fact sharing and clarifying understanding without any effort to expand or extend the information. *Other-regulation* is a term that has been used to describe one individual in a group temporarily taking on a predominate role in the group's interaction (e.g., taking an instructive role to guide group members) (Volet, Summers, et al., 2009). Other regulation can be high or low in quality based on whether the emphasis is on simple sharing or clarifying of information (low quality) or providing thorough explanations (high quality). Unfortunately, low-level social regulation is the type of regulation most typically observed in groups (Hurme, Merenluoto & Järvelä, 2009; Salovaara & Järvelä, 2003; Volet, Summers, et al., 2009).

Rogat and Linnenbrink-Garcia (2011) extended Volet, Summer, and Thurman's (2009) research by examining socially shared metacognitive and behavioral regulatory sub-processes demonstrated by a group to explain variations in the quality of SSR. They identified positive and negative qualities of group regulation: high quality planning, low quality planning, high quality monitoring, low quality monitoring, high quality behavioral engagement, and low quality behavioral engagement (Rogat & Linnenbrink-Garcia, 2011). When working in a group, planning refers to instances in which the group intentionally sets task-specific goals for learning and task performance. Monitoring, on the other hand, references a group's ability to understand the process during their joint work on a task (Rogat & Linndenbrink Garcia, 2011). Specifically, monitoring refers to the way a group evaluates their content understanding, the plan, and the progress. Behavioral engagement is the process groups use to involve group members, or not. For example, behavioral engagement occurs when the group eliminates distractions and encourages other group members throughout the task (Pintrich, 2000; Rogat & Linnenbrink-Garcia, 2011).

After analyzing these sub-processes, Rogat and Linnenbrink-Garcia (2011) determined that groups that were the most effective in SSR tended to display high levels of all three regulatory processes (e.g., planning, monitoring, and behavioral engagement). Groups that displayed less effective SSR tended to only demonstrate high levels of one dimension (e.g., monitoring), which could not compensate for lower levels of other dimensions. Rogat and Linnenbrink-Garcia (2011) were also able to make clear distinctions between high, moderate-high, moderate, moderate-low, and low quality social regulation. These findings make it possible for future studies to establish criteria for high and low quality SSR within small groups, as their results clearly delineate expected characteristics seen in groups when members are using the social regulatory processes individually and collectively. Having an awareness of, and being able to foster, students' use of these metacognitive processes for socially shared regulated learning is important because they enable students to be increasingly aware, knowledgeable, and decisive in their approach to learning.

Rogat and Linndenbrink-Garcia (2013) also conducted further analyses examining socioemotional group processes (i.e., positive and negative socioemotional interactions, collaborative and non-collaborative interactions). Positive socioemotional interactions were identified as group interactions that were congenial, such as instances of group members listening and respecting one another. Positive socioemotional groups also exhibited inclusion and group cohesion. Conversely, negative socioemotional interactions were group interactions that were not congenial, including instances where group members were disrespectful or would discourage other members from participating. Overall, researchers found lower group cohesion in groups that exhibited negative socioemotional interactions. Collaborative interactions were defined as those which included two or more members of a group interacting by sharing ideas and working jointly when problem solving, while non-collaborative interactions were defined as instances in which individuals worked on separate portions of the task at the same time or completed the task independently in unsystematic ways. Essentially, these researchers were also able to clearly define the role of socioemotional interactions in helping to differentiate between high, moderate-high, moderate, moderate-low, and low quality social regulation. For example, groups that displayed positive socioemotional interactions gave feedback to one another and monitored as a group, which was considered high quality social regulation. Those groups that exhibited collaborative interactions also demonstrated a higher quality of socially shared regulation because of increased opportunities to regulate the group as part of collaborative work on the task, especially during planning and monitoring phases.

Ultimately, researchers concluded that a group as a whole must plan, perform content processing, and engage in positive socioemotional interactions throughout the entire learning process in order to facilitate effective, socially shared regulated learning. Rogat and Linnenbrink-

Garcia (2011; 2013) also suggest that further research should examine which instructional designs foster high quality SSR since shared planning, shared monitoring, and behavioral engagement are essential skills to practice. They also suggest placing a strong emphasis on identifying interventions that foster positive interdependence, a prerequisite for collaborative learning environments to be successful (Johnson & Johnson, 2005).

Social Interdependence Theory. Social interdependence theory (Deutsch, 1949), has been used to explain how student interactions influence the outcome of group work. Three types of interdependence exist—positive, negative, and no interdependence. Positive interdependence occurs when group members contribute equal effort to a task in order to reach common goal (Johnson & Johnson, 2009). Research has found that positive interdependence is positively correlated with individual group attainment, or the successful completion of tasks, as it often results in a greater number of instances in which group members help, share, and encourage each other throughout the task. These helpful interactions tend to motivate the group toward the accomplishment of the shared goal (Deutsch, 1949; 1962). When negative interdependence exists, there is a negative correlation with individual group attainments because individuals within the group fail to obtain their goals. These interactions result in unproductive or oppositional interactions where individuals feel discouraged and make fewer efforts to complete the tasks (Johnson & Johnson, 2005). No independence exists when there is no correlation between individuals' goal achievements, in other words, individual group members do not consider the achievement of their goals to be related to the goal achievement of others.

Social constructivist, sociocultural, and shared cognition approaches emphasize that collaborative learning environments should be structured in order to be successful (Resnick, Levine, & Teasley, 1991). Along these lines, social interdependence theory argues that the type of interdependence structured into a situation determines how individuals interact with each other; which, in turn, largely determines outcomes (Deutsch, 2006; Johnson, 1970; Watson & Johnson, 1972). Group membership and interpersonal interaction among students has not been found to produce higher achievement unless positive interdependence is clearly structured. As a result, an educator designing a learning environment that fosters positive interdependence needs to consider the theoretical roots of strategies for motivating individuals toward this practice. There are a number of way of structuring positive interdependence, including positive goal interdependence, positive reward interdependence, and positive resource interdependence. Positive goal interdependence takes places when students perceive that they can achieve their learning goals if all members of the group also attain their goals. To encourage this a teacher has to include a clear group, or mutual, goal as part of the task. Positive reward interdependence occurs when each group member receives the same reward when the group achieves a common goal. Co-evaluative instruments embedded into designs, such as the team assessments used by Manente (2014), can be used as way to motivate students to engage in positive group interactions because they are aware that their group members will be providing feedback on their performance. Another strategy would be a teacher assigning the same group grade for all members. Positive resource interdependence occurs when each member has only a portion of the resources, information, or material related to the task to be completed; thus, the members' resources have to be combined for the group to achieve its goals. For example, teachers may provide a group with limited resources (e.g., one copy of the task or problem or a single sheet of paper to create a concept map) so that they must share or divide part of a required resource that the group must then fit together at the end. According to Johnson and Johnson (2002), combining goal and reward interdependence increases achievement to a greater degree than goal interdependence alone. Additionally, they have found that resource interdependence does not increase achievement unless goal interdependence is present also.

Similar to Rogat and Linndenbrink-Garcia (2011), Panadero and Järvelä (2015) suggest that positive socioemotional strategies and interdependence might be crucial for the activation of SSRL strategies within groups. Research on regulatory processes has demonstrated that these are important characteristics when designing a collaborative learning context, and these researchers have proposed that future research should consider how collaborative learning designs can encourage these regulatory processes by determining which forms of instruction, teaching practices, and scaffolds are most appropriate for these learners.

Strategies for Fostering Social Interdependence. While students often have some idea of their own style of working and self-regulation on tasks, an important benefit of collaborative learning environments is that social interaction provides opportunities for students to also learn about how they work with others on a shared task. Often student may view themselves as focused and diligent workers when individually responsible for their grade, and may think that behavior would translate into their group work. However, once placed in a collaborative learning environment, they may find that they actually tend to become easily distracted and dependent on others to complete tasks. This points to a fundamental concept in fostering motivation and learning— accountability. When there is nothing in place to encourage student accountability for individual performance, it is not uncommon for group members to demonstrate a high degree of off-task behavior, social loafing, irrelevant socialization, and tendencies toward focusing on a limited set of ideas. Groups may also fail to visualize the task as a shared problem, which prevents members from sharing a collective vision, taking collective action, and devising a collective solution (Cañas & Novak 2015; Chinn et al., 2011; Gillies & Boyle, 2010; Hogan & Tudge, 1999; Kohn, 1992; O'Donnell, 1994).

Research looking at strategies for increasing accountability and collaboration within groups has explored the impact of several instructional designs (e.g., independent, positive interdependence, and high positive interdependence) on student behavior (Manente, 2014). Independent group designs involve group members being given a shared task, but each earning a final grade that does not depend on the performance of their group members. In contrast, positive interdependence group designs may involve individuals working together on a problem, but do not require or encourage students to work together in order to equally contribute to the group product. And, lastly, high interdependence group designs involve students working together on a problem, and then completing an assessment in which team assessment occurs, holding everyone accountable. Team assessment requires all students within a group to complete an assessment, after completing the assessment the assessment is scored and a grade is earned by averaging all of the group members' scores. Studies comparing these designs have found that High Positive Interdependence designs lead to the greatest degree of collaboration and accountability between group members and better overall performance outcomes (Manente, 2014). Independent designs, on the other hand, led to the lowest scores. Thus, while more research is certainly needed to confirm that team evaluation increases positive outcomes associated with PBL, it is clear that collaboration is a necessary component of PBL (Manente, 2014).

Problem-Based Learning. The frameworks discussed above demonstrate the active role students have in constructing their knowledge while working collaboratively to engage in inquiry and problem solving. Social interdependence theory posits that group structure plays a large role in successful collaborative group outcomes. If collaborative learning takes place in authentic, or real-world settings students have the opportunity to apply their knowledge to real problems which can foster the acquisition of knowledge and problem-solving skills and, in turn, motivate students. One strategy for creating collaborative learning environments is using problem-based learning (PBL).

PBL is a student-centered instructional approach. In PBL the students are presented with an ill-structured problem that relates to authentic material (Torp & Sage, 2002). PBL allows students to investigate and solve complex problems with the support of peers and or the instructor. Strategies for the design of PBL environments have primarily been based on constructivist theories of learning. Constructivist learning theory proposes that people are active agents in building meaning through their personal interactions with their environment in collaboration with their fellow group members (Hmelo-Silver, 2006; Loyens & Gijbels, 2008). Constructivist learning theory supports PBL designs because students must exhibit self-directed learning in order to construct new knowledge while researching and sharing ideas with peers when solving real-world problems. Through this, PBL has been demonstrated to be an effective educational approach in higher education as it allows learners to work together, explain ideas, pose questions, and develop new perspectives in order to solve complex problems (Major & Palmer, 2001). PBL challenges group members to become active, self-directed learners and reflective thinkers who, in collaboration with others, take responsibility for their own learning process as they work to achieve a solution to the problem (Gijbels, Van de, &Dochy, 2005; Hmelo-Silver, 2004; Hmelo-Silver & Barrows, 2008).

As mentioned, the real-world problems posed to students in PBL are ill-structured, which means they have more than one solution and each solution can be reached via multiple paths (Torp & Sage, 2002). Designing an effective problem is not an easy task. In some PBL contexts students are confronted with problems that are too well-structured with a clear solution, which may decrease student motivation or prevent them from further constructing knowledge during the collaborative learning experiences (Jonassen, 1997). This occurs because students do not have the opportunity to identify gaps in their knowledge, and conduct research to fill these gaps in order to generate a solution to the problem. Thus, the more complex and more ill-structured a problem, the more likely it is that students will be motivated to engage in PBL. In addition to being thoughtful about the problem design, instructors using PBL must also be aware of how well group members are working together and how to effectively provide the appropriate support to ensure on-task behavior and active participation by each group member (Hmelo-Silver, 2004; Loyens, Magda, Rikers & 2008; Newman, 2005).

Learning Strategies to Support Problem-Based Learning Designs

Instructors have numerous responsibilities in PBL environments, including having a sound understanding of PBL, curriculum design, and task assessment. Most importantly, however, they need to create a PBL environment that is conducive to their students' abilities to learn the content (Torp & Sage, 2002). Effectively teaching PBL requires an instructor to identify and put in place supports for students to use throughout the learning experience as the instructor transitions from teacher-as-an-information-giver to teacher-as-a-facilitator. The instructor ultimately has the responsibility of moving from the role of teaching and providing knowledge to being a facilitator who ensures that each group's members are working together, staying on task, and taking responsibility for their own learning.

Scaffolding. Thus, the instructor needs to consider which supports are best suited for their learning environment before presenting students with PBL. One such construct, that has been referenced in theory and found to foster successful group processes when implemented in educational settings, is scaffolding (Quintana et al., 2004). Quintana, Reiser, Davis, et al. (2004) define scaffolding as assistance provided by an individual, or instrument made by an instructor, which is intended to help a learner acquire further skills or knowledge. Researchers have traced the origins of the concept of scaffolding, by a peer or guidance of an adult, back to theories related to Vygotsky's Zone of Proximal Development (ZPD) (Ashman & Gillies, 2013; Hogan & Tudge, 1999). As cited in Ashman and Gillies (2013), Vygotsky (1978), stressed the importance of social exchange in learning, especially between learners who are in the same ZPD. He believed that individuals who were around the same level of cognitive development could essentially be given a topic or problem scenario, and would be able to engage in an active exchange of ideas which would mutually enhance each other's learning. Additionally, Vygotsky (1978) proposed that assistance from a knowledgeable other, or an expert, could support learning even further.

In a classroom setting, many students are not prepared to undertake complex tasks on their own without assistance. Therefore, teachers must provide support to enable students to solve complex tasks successfully. Teachers can employ two forms of scaffolds into their instruction—*soft* scaffolds and *hard* scaffolds (Glazewski & Ertmer, 2010). Soft scaffolds are provided in the moment, or on a just-in-time basis, as needed depending on the learner's performance when completing a task. This occurs constantly in PBL as the instructor facilitates learning by observing students in their groups, identifying the appropriate soft scaffolds, and implementing them in order to guide students as they solve the problem. For example, in PBL after diagnosing needs, a teacher might mentor learning, encourage the process, question student thinking, or model inquiry to help students progress (Torp & Sage, 2002).

Hard scaffolds are planned in advance by the instructor, with the goal of helping to prevent student frustration by providing support that could aid with anticipated challenges that a typical student might be expected to face in a problem solving task. For instance, a hard scaffold could be a handout that has specific prompts and supports to help guide the students during the various stages of a problem solving task. An information gathering sheet is one hard scaffold that researchers have used to help learners plan and determine how they would approach solving a problem in a PBL environment (Manente, 2014). While completion of the sheet may initially be a requirement for students, the sheet can essentially be removed, or used as-needed, by the learners once they have gained the skills to plan the problem solving process on their own. This also demonstrates a key component of effective scaffolds—the ability to foster learning so that students eventually no longer need the support. Ultimately, both forms of scaffolding can be used in conjunction such that students' use of hard scaffolds may reduce the need for the instructor to provide soft scaffolds, but soft scaffolds can continue to be provided as needed based on the instructor's assessment. Saye and Brush (2002), note that these scaffolds are a crucial component to include during student-centered instruction.

In order to ensure that learners can eventually make progress independently, it is essential for an instructor to utilize the most appropriate scaffolds for the learning environment (Hogan & Pressley, 1997). It is also important for an instructor to determine whether providing scaffolds individually or to an entire working group is the best fit for the collaborative learning task and environment. The teacher needs to select the correct method so that students are empowered as investigators and, as they apply knowledge and skills to meaningful and authentic activity, are able to emerge as self-directed learners (Azevedo & Jacobson, 2008; Hmelo-Silver & Barrows, 2006; Palincsar & Brown, 1984). As stated, a key factor in students being able to grow in this way is the requirement that instructors fade their presence and take on the role of a coach, supporting students in generating their own possible solutions and problem resolutions. Ideally, instructors should fade out hard and soft scaffolds based on an assessment of student performance (Saye & Brush, 2002). However, the ability to fade out scaffolds appropriately takes practice and requires the instructor to be knowledgeable of the material, aware of student abilities, and intentional about how to proceed with fading. While support provided in the form of scaffolding should be dependent on the learner's performance, if an instructor misunderstands how much support a learner needs, it could result in too much support. Thus, the learner may become dependent on the assistance of the teacher or tool, or the individual may not have the opportunity to demonstrate their competence with a skill (Saye & Brush, 2002). Conversely, if an instructor provides too little scaffolding, the individual or group may struggle and become frustrated. Unfortunately, the need to systematically fade support is often overlooked by many instructors who attempt to practice scaffolding techniques (Saye & Brush, 2002).

Studies have shown positive outcomes for students in environments in which scaffolding is provided based on the learner's performance; however, these outcomes have been linked to one particular type of soft scaffold—prompts (Lee et al., 2014; Quintana et al., 2004; Perry, Thauberger, Hutchinson, 2010). Prompts are hints, or reminders, that inform the learner that further action needs to be taken (Xun & Land, 2004). Prompts can be in the form of questions, phrases, scripts, lists, procedural directions, or reflections (Hadwin, et al., 2010). A more specific type of prompt could be in the form of a problematizing scaffold, which requires students to focus their attention on certain issues of the task, and reflect on their work product by discussing their findings through thoughtful discussion (e.g., articulation and reasoning) (Reiser, 2004). Ultimately, prompts produce positive student learning outcomes because of their ability to support learning, enhance metacognitive planning and reflection, and improve content understanding (Davis, 2006; Quintana et al., 2004).

Embedded scaffolds, a sub-category of hard scaffolds, are typically available to students throughout the entire learning session, and students can decide whether or not to use them. According to Azevedo and Jacobson (2008), "these types of scaffolds are usually designed to facilitate metacognitive monitoring" (p. 97), or the ability to understand or be aware of ones' thought process. While instructors initially empower students to be investigators of a PBL problem, their ultimate goal is to foster metacognitive monitoring by slowly relinquishing control and coaching students to engage in greater self-monitoring and self-direction (Torp & Sage, 2002). A structured scaffold is another sub-category that is specifically used to help students focus by simplifying the task or breaking it into smaller portions which may be more manageable for the students (Reiser, 2004). For example, the information gathering worksheets used by Manente (2014) would be considered a hard scaffold, embedded scaffold, and structured scaffold because learners could use them for support as needed throughout the planning phases of each problem solution.

While building group regulatory skills is important, recent research has claimed that doing so can be ineffective in problem-based experiences unless instructors also consider student motivation particularly as it relates to subsequent engagement (Belland, Kim, & Hannafin, 2013; Martin, 2012). As a result, researchers have developed a framework for designing scaffolds that works to enhance group success by focusing on how motivation relates to behavioral, emotional, and cognitive engagement (Belland et al., 2013). Their framework proposes that motivation-enhancing scaffolds in PBL should promote six goals, which are broadly supported by motivation theories: task value, mastery goals, belongingness, emotion regulation, expectancy for success, and autonomy. They argue that increasing motivational scaffolds to support each of these goals would enhance the three areas of engagement, thus improving students' problem solving process (Belland et al., 2013; Fredricks, Blumenfeld, Paris, 2004; Lee & Schute, 2010). Concept maps are one tool that can be used as a motivation enhancing scaffold in student-centered learning environments, particularly for PBL.

Concept Maps as a Tool for Supporting Learning

A concept map is a tool that can be used to provide students a space to create visual diagrams in which they graphically organize the interrelationships between their original knowledge of complex concepts and information related to newly acquired concepts (Jonassen & Hung, 2006). When drawing a concept map, the first step is to identify a main concept or topic and then draw lines to link or connect that concept to other closely associated concepts represented in squares or circles called nodes. Nodes can also be linked to each other by lines as well to represent relationships between various minor concepts. Generally, major concepts are within closer proximity to the main concept or topics, while the minor concepts are further away.

There are three types of mapping techniques: construct-a-map technique, fill-in-the-map technique, and expert-map technique (Cañas, et al., 2003). The construct-a-map technique requires students to complete a map independently, while the fill-in-the-map technique provides students with a partially filled-out map and requires them to complete the rest. Lastly, the expert-map technique involves an instructor giving students a pre-structured map. Both, the construct-a-map and fill-in-the map techniques result in a greater increase of knowledge because they require students to become more active participants in the construction of their maps by identifying how concepts are related (Hardy & Stadelhofer, 2006; Novak & Cañas, 2008). The construct-a-map technique is most often used for situations in which students need to solve a problem that has multiple solution paths, such as the problems presented in PBL.

As a learning strategy, concept maps allow learners to create a structure which helps them to recognize problem components, visualize conceptual relationships, hypothesize solutions, effectively retrieve information, and discover new ideas. Ultimately, in doing so, students are able to make new connections and confirm solutions to the problem, while teachers are able to use the maps as a representation of students' knowledge and as a guide to help determine scaffolding needs throughout the problem solving process (Jonassen & Hung, 2006; Liu, Chen, & Chang, 2010).

Learning theories underlying the use of concept maps. Numerous theories have been cited as part of the rationale for understanding concept mapping, including constructivism, assimilation theory, knowledge representation, and meaningful learning (Anderson, 1995; Ausubel, 1963; Novak, 1990). Concept mapping was introduced by Novak and Gowin (1984), and was founded on the principle of constructivism which emphasizes the critical role that learners play in constructing and developing knowledge and meaning from their experiences and beliefs (Conceicao & Taylor, 2007; Duffy, Lowyck, & Jonassen, 1991). Per this theory, learners bring their previous knowledge and personal experiences to the classroom, and use this knowledge to solve problems and form meaning based on their experiences.

A second foundational theory of concept maps is Ausubel's (1963) assimilation theory which asserts that learning occurs through the assimilation of new concepts into a learner's existing understanding of a concept. A learner's existing knowledge base is also referred to as the individual's *cognitive structure*, and Ausubel's primary idea is that individuals learn by subsuming, or absorbing, new information into this cognitive structure (Novak & Cañas 2006). In this theory ideas are connected in hierarchical order, and it follows that more specific and detailed concepts are subsumed under more inclusive and general ones. Ausubel believed that having an obvious and well-categorized cognitive structure facilitated learning and the retention of new information.

Another significant contribution was Ausubel's (1968) distinction between *meaningful learning* and *rote learning*. He proposed that meaningful learning occurs when learners consciously integrate new knowledge into relevant concepts about which they are already aware. In meaningful learning, or by subsuming information, learners store new information in long-term memory along with similar and related knowledge in order to remember and understand the new knowledge. In contrast, rote learning occurs when one memorizes concepts, but does not necessarily make connections or understand the relationship a concept has with other concepts. Rote learning may eventually contribute to the construction of a new schema which can be used in meaningful learning. Mayer & Moreno (2003) proposed three processes as being essential to the development of meaningful learning: attending, organizing, and integrating. In other words, to engage in meaningful learning, learners should concentrate on the relevant and important content, organize the content structurally, and integrate the content into their existing cognitive structure. In addition, Novak and Gowin (1984) identified three fundamental requirements for meaningful learning based on Ausuel's work (1963): the learner's relevant prior knowledge, the teacher's construction of meaningful material, and the learner's conscious choice to use meaningful learning. Like Ausubel (1963), they asserted that rote learning resulted from little relevant prior knowledge, and the lack of ability to relate new knowledge with relevant or existing knowledge. Based on these theories, concept maps are an ideal method to promote meaningful learning because they provide a clear structure that requires students to actively connect new concepts and existing knowledge in ways that other learning tools may not.

In addition to the theories on which concept mapping is based, the utility of concept maps has also been explored in numerous studies (Burgess-Allen & Owen-Smith, 2010; Nalavany, Carawan, & Rennick, 2011; Ridde, 2008). Studies have shown that concept maps promote motivation to learn, enhance critical thinking and problem solving skills, and promote higher-order thinking skills (Daley & Torre, 2010; Edwards & Cooper, 2010; Smith, 2014). Daley and Torre (2010) also explored the use of concept maps in teaching PBL and group learning. They found that concept maps promote meaningful learning, provide an additional resource for learning, enable instructors to provide feedback to students, and can be used to conduct assessment. Ultimately, there is strong theoretical and research-based support for the valuable role that concept maps can play as an aid in scaffolding student learning, particularly in PBL environments.

Concept maps as a tool in Problem-Based Learning. Ultimately, the ability to work effectively in a group is a highly beneficial skill for students to develop and utilize as they move into the workforce; however, it is also one that has proven challenging to successfully foster in educational contexts. PBL has been identified as a teaching strategy that can help students learn to work effectively in collaborative settings, particularly when instructors work to foster socially-shared regulation and use appropriate scaffolding strategies. According to Belland, Kim, and Hannafin (2013), ideal scaffolding strategies are ones that promote student motivation to learn by increasing their sense of task value, mastery, belongingness, emotional regulation, expectancy of success, and autonomy. The use of concept maps as a way for an instructor to provide support has been demonstrated to have many positive impacts on the educational outcomes for students, both in traditional and PBL environments; and there is also significant evidence that their use can serve as an ideal scaffold across many of the motivation domains listed above.

Task value. When designing a PBL experience the teacher needs to consider context and curriculum, as well as which instructional strategies are most likely to promote a sense of task value for the students (Torp & Sage, 2002). Task value is defined as how students' perceive the task and based on their perceived worth, dedicate time to completing the task, or the degree to which a student will find a specific task interesting. This is an important consideration even within the context of a single course in which all students are enrolled, because their level of interest in the course material or assignments may vary widely. For example, though college students typically choose their own major, they are often required to take specific courses within the major that may or may not interest them. As a result, it is important for instructors to identify ways of establishing task interest for each student.

When students begin a PBL experience it can be very frustrating for them, because it is often a new way of learning with which they are unfamiliar. Thus, when considering how to foster task value, it is important for the instructor to explain PBL and how it works to students in order to create buy-in or attainment value before beginning the PBL experience. One way of doing this is for teachers to provide explanatory rationales which emphasize how engaging in the PBL process and solving the problem will contribute to the development of problem-solving, collaboration, and self-directed learning skills. Teachers can also clearly communicate how the content knowledge will be beneficial for the students' daily lives and futures as well. These steps can promote task value because they help students recognize the larger-scale and long-term benefits they can gain from the experience. An instructor could also explain how collaboration is part of many workplace environments. In order to foster task value related to the use of concept maps, an instructor could stress their utility in theoretical and clinical settings by explaining to students that they can be used to help improve critical thinking skills by providing students to visual forum to make relations between concepts, or explaining that in a practical setting concept maps have been used to organize data in a workplace setting (Harrison & Gibbons, 2013).

Another way of establishing interest and promoting task value is to create a problem scenario that is based on a real-life situation, is meaningful to the students, and affords them the opportunity to make choices throughout the learning experience (Merriam & Bierema, 2014). Offering students choices promotes interest because if students are involved with making a decision it increases the likelihood of students seeing task value due to their propensity to want see the completion, or outcome of their decision making. Providing the students with choice is inevitable in PBL because a true PBL environment requires the teacher to pose a problem that is ill-structured and has more than one solution path. Additionally, however, the teacher can also foster student choice by having students develop concept maps of the problem and concepts closely associated with the problem topic. When making a concept map, students are able to choose which concepts they perceive are closely associated with the main area of study. They can also choose to elaborate, however they would like, on areas that they consider to be more interesting individually or as a group. If a student is having a difficult time understanding where to begin when solving the problem, another way to foster choice, in the form is scaffolding, is to provide students with different pieces of the problem that need to be solved, and incorporate student choice by allowing them to choose what part of the problem they want to solve and what resources they would like to use as they work toward a solution (Belland, et al., 2013).

Lastly, the teacher can establish task value by asking students driving questions related to their map to generate interest and encourage them to revise or enhance their solutions to the problem by helping to create cognitive conflict (Keller, 2010; Limon, 2001; Pintrich & Schunk, 1996). For example, a teacher may ask students to communicate how two concepts are related on their map, even if students did not connect the two concept in their drawing. Or a teacher may ask students to differentiate between two concepts that seem closely related (e.g. differentiated self-regulated learning from self-directed learning). Presenting students with questions that give them options for the approach they take, as well as the products they produce, in solving the problem is another way to increase their sense of buy-in and perceived task value (Blumenfeld, Soloway, Marx, et al, 1991). Additionally, something as simple as keeping the target question on display throughout the activity can help remind students of the purpose of the task, establish group collaboration, and ultimately increase engagement (Clinton & Van den Broek, 2012). One of the most important ways that the instructor can promote task value for students in PBL is to effectively transition from teacher-as-information-giver to teacher-as-coach, and to use the role of coach to support student inquisitiveness, question their thinking, and challenge them to justify their conclusions.

Mastery Goals. The second way to support motivation is to help students develop mastery goals, or goals that place emphasis on learning new skills, improving or developing competence, and gaining understanding while trying to accomplish something challenging (Linnenbrink-Garcia, Pugh, Koskey, Stewart, 2012). Mastery goals contribute to deeper processing, which is also associated with pursuing rationale goals (Chinn & Buckland, 2012; Pugh, Linnenbrink-Garcia, Koskey et al., 2009; Sins, van Joolingen, Savelsbergh, & van Hout-Wolters, 2008). Rational goals is defined as, “the aim to engage with content and processes in epistemically authentic ways" (Belland et al., 2013, p.255). Rational goals exist when, students explain concepts by stating claims and support their claims with facts, demonstrate the ability to communicate relationships, listen and analyze arguments to determine if the facts are understandable and logical (Chinn, Duncan, Dianovsky, & Rinehart, 2013). Pursuing rationale goals is essential to solving authentic problems such as the ones found in PBL, and aids in students achieving mastery goals in PBL environments (Barrows & Tablyn, 1980; Chinn et al., 2013; Hmelo-Silver, 2004; Jonassen, 2011). The use of scaffolds has also been found to help foster mastery goals and facilitate learning; while the encouragement of short-term goals, delivering informational feedback, and promoting cooperation rather than competition have all been found to foster the development of mastery goals as well (Ryan & Deci, 2009; Pugh, et al., 2009).

Initially, teachers can give prompts and a problem space in which students can break the mastery goal into short-term goals. Concept maps can then be a way to assist students with the establishment mastery goals by providing and promoting informational feedback (Levesque, Zuehlke, Stank, & Ryan, 2004; Reeve, 2009). Mastery goals are important because they are strongly associated with self-regulated learning (Cellar, Degredel, Sidle, et. al, 1996). Concept maps have been used a cognitive tool to help students organize their knowledge and learning experiences and increase self-awareness through reflective thinking (Kao, Lin & Sun, 2008). Use of these maps allows students to think deeply about a concept and store the information effectively in memory (Hwang, Yang & Wang, 2013). It also reduces cognitive load (Hu & Wu, 2012). Additionally, the effectiveness of a concept map as a tool, to help students organize their knowledge and increase mastery, can be improved by providing students with instant feedback to revise their work (Hu &Wu, 2012).

While students' concept maps provide instant feedback, other forms of feedback can be produced during and after the production of the maps. For example, peer feedback on maps challenges students to critically rethink the concepts and connections on the map to determine if they want to change the maps to be more similar to their peers or if they find that it truly represents the way they understand the material (Middleton & Midgley, 2002). Informational feedback, or feedback on and individuals (or groups) progress, is also important, as it influences students' decisions to pursue mastery goals by helping students understand what they have completed and its contribution to the final product, it also can help students identify what they should focus on as they continue to pursue the completion of the overall task (Elliot & Dweck, 1988). Concept maps can also be used to determine change in understanding by employing it before, during and after the task activity or lessons. It can provide the instructor with an opportunity to evaluate student progress, highlight areas of improvement, and determine how to direct the lesson by providing both formative (ongoing) and summative (final) feedback or assessments (Lee et al., 2013). For example, a formative assessment could be the instructor reviewing the concept map during the PBL process and providing driving questions related to the way concepts are connected. Additionally, an example of assessment could be an instructor using the concept map to assess student learning through student presentations on the maps or by using rubrics that contain essential connections that should be present on the maps.

Another important factor in the acquisition of mastery goals, as well as in the development of interdependence, is the ability for two or more individuals in a group to develop and pursue shared goals (Johnson & Johnson, 2008). In order to do this, the instructor should encourage the group to consider the ideas of all members (Tomasello, Carpenter, Call, Behne,& Moll, 2005). Other ways to encourage shared goals include prompting students to co-construct standards and to establish social goals, or goals that are pursued when interacting with others (e.g., helping others). Allowing students to construct their own standards, rather than imposing standards on them, helps them feel like they are part of the group (Chinn et al., 2013; Reeve, 2009). Instructors can also encourage group members to exhibit positive behavioral regulatory strategies and cognitive regulatory strategies in an effort to achieve mastery goals. For example, fostering socially shared regulatory strategies such as behavioral engagement would help students keep each other on task, as students would encourage off-task group members to refocus and praise other group members who remained on task. Both of these efforts could increase the likelihood of group members accomplishing their goals and increase the quality of this form of regulation. In addition, the use of cognitive regulatory strategies could help students better plan how they will solve the problem, monitor progress, and evaluate whether they are meeting the expectations of their goals. Ultimately, researchers have made a strong case for encouraging mastery goals in classroom inquiry contexts (Linnenbrink-Garcia, et al.,2012), and have demonstrated how strategies such as encouraging shared goals, accommodating social goals, and co-constructing shared standards can both help with the development of mastery goals and also promote another key component of motivation—belongingness.

Belongingness. Belland, Kim, and Hannafin (2013) define belongingness as “the psychological need to perceive connection with others during conduction of tasks” (p. 24). This factor has been found to be crucial to group work; and, given the reliance of PBL on group work, belongingness is also essential to foster in PBL environment. As a first step, instructors should teach students to focus on cooperation rather than competition as they work toward shared goals (Wigfield et al., 1998). Studies have shown that cooperative learning can improve student motivation by fulfilling a need for connectedness and allowing groupmates to learn from each other (Ryan & Deci, 2000; Johnson & Johnson, 1985; Osterman, 2000; Schunk & Zimmerman, 2008). It is important to note that the nature of the positive interactions between participants appears to have an influence on whether the effects of collaboration are positive (Chinn, O'Donnell & Jinks, 2000; Van Boxtel, Van Der Linden and Kanselaar, 2000; Linndenbrink-Garcia & Rogat, 2011). Thus, instructors should work to help students to foster positive interactions through strategies that increase SSR.

Multiple studies have been dedicated to determining the benefits of collaborative concept mapping. For example, some researchers have noted that when used collaboratively, concept maps promote questioning, discussion, and debate (Baroody & Bartels, 2000; Baroody and Coslick, 1998) noted that when used collaboratively, concept maps promote questioning, discussion, and debate. Stoyanova and Kommers (2002) found that interdependence was a vital contribution to group concept mapping and resulted in greater quality of collaboration, and resulted in a more dense conceptual representation than did mapping in groups where members did not have equitable investment and contribution. Chiu, Huang, and Chang (2000) explored group interaction during collaborative web-based concept mapping, and found that a type of high-level interaction called *complex co-operation* correlated most highly with mapping performance. Okamoto and Cristea (2001) described a concept mapping environment designed to support collaborative course authoring, given their belief that the mapping process can be useful for course designers because of its theoretical basis. They suggested that concept mapping leads to increased creativity, as well as the effective externalization and visualization of ideas. Francisco, Nicoll, and Trautmann (1998) reported that repeated use of concept maps during review sessions throughout a college-level chemistry course resulted in students building a collaborative, integrated view of the topics covered in the course. Overall, there is strong support for collaborative concept mapping as a beneficial tool in group work, in part because the co-construction of the map promotes belongingness because it requires members to consider one another's ides when the map.

The benefits of collaboration in concept mapping have also been thoroughly researched in regard to student performance on assessment. Esiobu & Soyibo (1995) compared group and individual performance using concept mapping, vee mapping, or no instructional support, as a way to summarize information or use the instructional support as a way to study following regular classroom instruction. When students used the instructional supports and worked with others, they performed best on a multiple-choice assessment. Previous research has also demonstrated the usefulness of collaborative concept mapping on student learning and outcomes when students are engaged in the actual process of constructing the map (Roth and Roychodury,1993).

Emotional Regulation. Another key component of student motivation is emotional regulation, or the ability to reflect on the process and promote accurate attribution to ensure students understand they have control of their learning. By highlighting the controllability of actions and promoting the reappraisal of failure instructors can support emotional regulation (Belland et al., 2013). As mentioned earlier it is important for an educator to remind students that they have control of what happens in their learning environments, because if students have a negative perception of the task, or their contributions toward the task, it can impede cognitive processes and affect how memories are encoded (Kim & Pekrun, 2014). Reappraisal refers to the process of reflecting on the context in which success or failure can occur, as well as reassessing the path which lead the outcome (Goldin, Mcrae, Ramel, & Gross, 2008). Ensuring that students have the ability to reappraise their experience is important because struggling during PBL is very common. Often, students' initial strategies for approaching a problem will not work, and there is a risk that frustration or negative emotions (e.g., fear of failing) might promote disengagement and withdrawal (Roseman, Wiest, & Swartz, 1994). However, if students are able to reappraise their experience then they can reflect on the context and reassess what lead to the outcomes, and adjust their way of navigating the situation accordingly. Promoting positive attribution, or ways in which the individual or group positively contributed to the product is important because it influences the expectancy for success and positive emotions, and teachers would have difficulty providing sufficient attributional feedback to all their students by themselves, therefore it is important the teachers ensure that if students have feelings of negative attribution they understand that they have control of their learning and turn things around(Weiner, 1986).

Studies have also explored the relationship between emotional regulation and concept maps. Lim, Lee, and Grabowski (2009) found that students with high self-regulated skills significantly outperformed those with low self-regulated skills in the production of concept maps. Another study by Chu, Hwang, and Liang (2014) investigated the effect of computer-based concept mapping on students' learning performance in web-based information seeking activities. They used a computerized cooperative concept mapping approach as a scaffolding tool to help students in interpreting and organizing data collected during the activities. They found that the students in the collaborative concept-mapping group had significantly better learning attitudes, self-efficacy, and achievement than those in the individual concept-map group. The collaborative group also had lower cognitive load than the traditional/individual group. Ultimately, concept maps are effective for organizing different concepts, visualizing the relationships between main concepts, or summarizing information in a meaningful way. This, in turn, improves student achievement and enhances student self-regulation, self-efficacy, and motivation (Chu et al., 2014).

Expectancy for Success. Wigfield and Eccles (1992) found that students who perceive a high value in task also have a high expectancy for success, or high expectations of their ability to succeed. Other researchers have found that students' expectancies and perceptions are linked to their level of cognitive engagement through elaboration, use of metacognitive learning strategies (e.g., planning, monitoring), and deeper processing of course content (Pintrich & Schrauben, 1992). Research associated with group learning has also focused on reliable process and its relation to the expectancy of success. Reliable process refers to the individual and group strategies and processes that consistently lead to good results when deployed to address a particular goal. For example, collaborative argumentation, or a situation in which two or more individual make claims and support claims with reason an evidence, is a process that has been found to lead to good ideas (Chinn & Clark, 2013). Identifying, and encouraging students to use, reliable processes can have at least three key benefits: high expectancy of success, mastery experiences, and enhanced credibility of knowledge (Chinn, et al., 2011). When creating a map, group members discuss relevant and irrelevant concepts and decide on the information that is important to place on their map. Ultimately, the way group members discuss this information allows learners to construct new meaning leading to better ideas.

Autonomy. Autonomy is generally positively associated with positive learning processes and outcomes, such as cognitive flexibility and deep learning (Assor, Kaplan, & Roth, 2002; Deci & Ryan, 1987). Additionally, according to self-determination theory, autonomy-supported environments can lead to higher levels of intrinsic motivation (Ryan & Deci, 2000). Research into motivation has identified three guidelines that instructors can use to promote autonomy:

using non-controlling language, providing meaningful cognitive choices, and helping students direct their own language. Instructors can also support student autonomy by reducing threats and pressures in the learning environment, as well as by providing opportunities for students to establish self-directed goals and make their own choices (Assor et al., 2002; Deci & Ryan, 1987). The use of concept maps fosters these types of opportunities, and can improve students' ability to learn autonomously and independently. Thus, using them as a scaffold in PBL can enhance motivation. When students engage in PBL units for weeks at a time, it is crucial to help them see that solving the problem is worthwhile, that it is something they can accomplish, and that they should press for understanding because it will help them gain more important skills. It is also important to reinforce the belief that they belong in the classroom community and in the profession, that they can respond to negative emotions in constructive ways, and they can do all of this while remaining in control of their own learning outcomes (Belland, et. al., 2013).

Summary

Collaborative learning environments such as PBL have been effective in promoting peer engagement, and enhancing skills of peer communication, peer understanding, and fostering deeper learning. By thoroughly examining the social processes of collaboration we can gain understanding of the group regulatory processes that occur, one that is important to further understand is socially shared regulation, a regulatory process that leads to deep-level learning strategies and transfer (Rogat-Linnenbrink-Garcia, 2011).

Researchers who have studied socially shared regulation have suggested future research aim to determine ways to foster interdependence and identify learning designs that support high quality socially shared regulation. Collaborative concept mapping in conjunction with PBL has been an effective tool to support learners throughout all phases of the problem solving process, by aiding learners with reasoning, critical thinking, and the application of theoretical knowledge for understanding in the classroom and in real-world settings (Hmelo-Silver & Barrows, 2006). Concept mapping strategies support the idea that teachers should be facilitators to help students become active learners with the ability to construct new knowledge based on their own prior knowledge and experiences in collaboration with their peers. When combined with PBL, concept mapping increases students' interest and motivation to learn, promotes creative and critical thinking, promotes problem solving, helps students accomplish their autonomous learning goals, and has the potential to foster socially shared regulated learning (Cañas, Hill, Lott, et al., 2003; Daley and Torre, 2010; Hsu, 2004).

Purpose

The purpose of this study is to build on existing research to explore whether the use of concept maps within PBL learning environments could be considered a best practice for instructors in their efforts to help students effectively manage their collaborative experiences and learning. Manente (2014) and Lee, O'Donnell, and Rogat (2014) both conducted related research at Rutgers University within a course entitled, "Educational Psychology: Principles of Classroom Learning." The purpose of the course is to expose students to various psychological theories and pedagogical practices used by educators in multiple disciplines. Within this course, these researchers looked at the use of PBL, and the processes and indicators of quality SSR, respectively. The current study was also conducted within this course with the intention of combining these two bodies of research, and expanding upon them to explore ways in which the incorporation of concept maps might link the two areas. More specifically, this study replicated the multi-level PBL research design used by Manente (2014), with the addition of concept maps as part of the protocol for students. This was done to examine whether concept mapping contributes to the quality of SSR during the various forms of PBL instruction.

This study used a mixed-methods design to explore the following research questions:

1) Do concept maps serve as an adequate structure to scaffold student development of skills related PBL?
    d) Does the use of concept maps effect individual and group task and assessment performance? To what degree do concept maps affect individual test performance and group task performance?
    e)) Do conceptual gains produced on a concept map associated with change in performance outcomes on problem solutions, comprehension assessments, and finals?
2) What PBL instructional designs provide opportunities for students to engage in SSR?
    f) What kind of SSR processes are exhibited by students working on PBL activities?
3) To what degree do concept maps affect the quality of SSR exhibited within small group work?
    g) Are students engaging in high-quality SSR when using concept maps as a tool to solve problems?
    h) What student-centered PBL instructional designs provide for students to engage in high quality SSR when using concept maps as a tool?
    i) How does "team evaluation" foster a higher level of interdependence and sustained collaboration, which supports high quality social regulation?

Methods

Course

The interdisciplinary instructional unit took place during the fall of 2015 at Rutgers, The State University of New Jersey within one section of the course, “Educational Psychology: Principles of Classroom Learning.” The 3-credit class met one time per week and each class meeting was 3 hours. The objective of the course is to introduce undergraduate and graduate students to several theoretical perspectives related to learning, as well as to various pedagogical practices common in the field of education. Multiple sections of the course are taught throughout the school year, and course content is consistent across all sections. However, the instructional methods and materials that are used within each section vary depending on the course instructor. A mixed methods instructional format was used for the course section in which the study was conducted. This was noted in the course description provided to students at the time of registration to afford them the option of taking an alternative section of the course that used a more traditional lecture/discussion format. A mixed methods research approach in inquiry combines both quantitative and qualitative approaches. This method was chosen because, “it involves the use of both approaches in tandem so that the overall strength of the study is greater than qualitative or quantitative research” alone (Creswell, Plano, Clark, 2007; as cited in Creswell 2009, p.4).

Targeted Instructional Content

The course goals are meant to encourage students to become familiar with the theoretical principles and pedagogical practices common within the field of education today. The course is also designed to have students apply these practices to appropriate learning contexts. For this investigation, the instructor focused on content related to three distinct theoretical perspectives—

behavioral learning theory (BLT), cognitive learning theory (CLT), and social-constructivist learning theory (SCLT). Though a prerequisite psychology course was required to enroll in the class, students were not required to have pre-existing knowledge of the content related to either of these three perspectives to participate in the course or to understand any of the other perspectives. The three key topics were also independent of one another, and previous research demonstrated that practice effects did not influence the results on students' scores on problem solutions or comprehension assessments (Manente, 2014).

To control for any impact that the sequence in which the perspectives were presented might have on findings, this study presented the material in the same sequence used by Manente (2014). Behavior learning theory, which posits that learning occurs as a direct result of the influence of environmental stimuli on behavior, was presented first. The second key topic introduced was cognitive learning theory, which suggests that learning is the outcome of an individual's perception of environmental stimuli based mostly upon their prior experience or preexisting conceptions. The last key topic introduced was social constructivist learning theory, which asserts that learning results from the continual interactions that occur between individuals and their social world.

Participants

A total of 20 students enrolled in the section of the course associated with this study. While participating in the planned learning activities was a course requirement, the decision to have one's data and discussions video recorded and analyzed for the purposes of research was strictly voluntary. During the first class meeting students were provided with a physical copy of the syllabus and a detailed description of the course goals and objectives. The instructor explained the various activities that would take place throughout the semester and a description of the study was described in brief on the syllabus. The instructor, who is also the primary investigator, delivered consent forms and left the room while students completed them. A research assistant remained in the room to answer any student questions. The research assistant collected the completed forms and kept them under lock and key until the end of the semester. To avoid potential risk related to coercion and to decrease the likelihood of bias, the instructor remained blind to the identities of the students who had given consent to participate in the study until the final grades of the course were submitted at the end of the semester.

A total of 16 pre-service teachers and education minors at the undergraduate sophomore to graduate-level elected to participate in the study. Those students that elected not to be in the study engaged in the same activities as those who did. A teaching assistant accessed student consent forms to divide participants into four PBL groups as described below. The current study provides a quantitative and qualitative analysis of the data collected from these students.

Group Formation

During the last 30 minutes of the first class all the students took a pre-assessment related to the key topics (i.e., behavior learning theory, cognitive learning theory, social constructivist learning theory) that would be targeted for instruction during the three PBL sessions. The first question asked students to explain everything they knew about cognitive learning theory (CLT). The second question asked students to explain everything they knew about social constructivist learning theory (SCLT). The last question asked students to explain everything they knew about behavior learning theory (BLT). Once completed, the pre-assessments were collected for review by the instructor and the teaching assistant. Both the instructor and teaching assistant scored the pre-assessment using the level of complexity response rubric, see Table 1. Based on the rubric, students could earn a score ranging from 0 to 6. A score of ‘0’ indicated that the student did not identify concepts, provide a basic definition of the concepts, elaborate on the definition of a concept, provide a basic explanation, elaborated explanation, or demonstrate how they would apply the concept to real life-situation. Based on these scoring criteria, none of the students had demonstrated that they can apply concepts to any practical content. Some students (N=9) had prior knowledge of concepts associated with BLT, very few students (N=2) had knowledge of CLT, and none of the students had previous knowledge of SCLT.

Table 1

Coding system: Levels of complexity

Level	Characteristic	Description
0	No Mention	Fails to mention primary concept.
1	Identification	Identifies primary concept without providing 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 toward the implementation of a specific strategy in a practical context.

Note. From “Is Collaboration A Necessary Component of Problem-Based Learning?” (Doctoral dissertation). By, C. Manente, 2014 (https://rucore.libraries.rutgers.edu/rutgers-lib/44171/PDF/1/play/). Copyright 2014 by Christopher Manente. Reprinted with permission.

Once all the pre-assessments were scored, the teaching assistant created the groupings. The students who declined to participate in the study were grouped together, and the remaining students were divided into four groups with four participants in each group. When creating the groups, the teaching assistant used pre-assessment scores to ensure that each of the groups had an even distribution of, or equivalent total scores on, the degree of prior knowledge of each of the learning perspectives (see Table 2). Additionally, students were assigned to work with the same group for all three of the PBL cases, and each participant was not assigned a specific role (i.e., facilitator, recorder, materials manager, or presenter) in accordance with PBL principles which foster students taking responsibility of their own learning by identifying their own learning issues and needs. When working on the PBL cases, group members were expected to share ideas, positions, reasons, evidence, and feedback with each other.

Table 2

Group Allocation, Descriptive Information, and Pre-Test Scores

	Gender	Focus Topic		
		BLT	CLT	SCLT
Group 1	Female	1	1	0
	Male	0	0	0
	Male	0	0	0
	Male	3	0	0
Total		4	1	0
Group 2	Female	2	1	0
	Male	0	0	0
	Male	0	0	0
	Male	3	0	0
Total		5	1	0
Group 3	Female	1	0	0
	Female	3	0	0
	Male	1	0	0
	Male	0	0	0
Total		5	0	0
Group 4	Female	0	0	0
	Female	0	0	0
	Male	3	0	0
	Male	2	0	0
Total		5	0	0

Study 1: Incorporating Concept Maps into Problem Based Learning (PBL)

The first portion of this study utilized a design-based research approach with the goal of determining whether concept maps can serve as an adequate structure to scaffold student development of skills related to small group work. A secondary goal was to determine if specific PBL instructional methods, combined with the use of concept maps, contributed to greater task performance in comparison with PBL instructional methods alone. To do so, students' performance on problem solution and comprehension assessments were evaluated and outcomes were compared to the outcomes from the students in Manente's (2014) study.

The current study was also designed to examine the impact of concept maps on three different PBL conditions—PBL-Independent, PBL-Positive Interdependence, and PBL- High Positive Interdependence. The ordering of these conditions was modeled after Manente (2014), such that students performed PBL-independent, PBL-Positive Interdependence, and then PBL-High-Positive Interdependence conditions. By assigning the independent condition first, this instructor hoped to encourage students to become acclimated to, and competent with, the various PBL tools (i.e., information gathering sheet, problem solution worksheet, and concept maps), before asking them to engage in activities which required the use of additional skills related to collaboration. This was to avoid the potential for too much cognitive load stemming from having to engage with too many new skills and concepts simultaneously. Given the sequential presentation of similar PBL tools and concepts, the current design could generate practice effects such that a student's performance is directly influenced by repeated exposure to a treatment. However, previous studies have supported the use of this design, and data suggests that subject scores were not significantly impacted by practice effects (Manente, 2014; Pease & Kuhn, 2011).

Materials The materials used for this study are described below.

PBL cases. As described above, PBL consists of providing students with an ill-structured problem in the form of a case; allowing time investigate, research, and develop knowledge to address the problem; and then to use a problem solution worksheet (see Appendix C, Appendix, F, and Appendix I) to develop a 3 – 5 page solution for each case. In this study, students completed a practice problem in addition to the three problems that were associated with the three targeted concepts (i.e., BLT, CLT, and SCLT). Each of the problems replicated real world situations that educators could face in different learning contexts.

Before students were presented with a problem scenario they were instructed to read two articles on problem-based learning and group learning. After reading the articles students were to discuss the articles using an online forum. Students came to the next class meeting with questions associated with the article and a group discussion was held to discussed any lingering questions students might have had. Following the discussion the instructor reviewed the articles once more by constructing a concept map. The construction of the concept map and how the articles were integrated into the instruction are further detailed below.

The practice case focused on the topic of Bloom's Taxonomy (1956). Students were asked to assume the role of a parent taking their 10-year old twin boys on a trip to a zoo, and the case task required them to create an itinerary for the boys to engage in activities before, during, and after their trip to the zoo. Students were asked to create a plan which promoted higher-level thinking in order to create a rich educational experience at the zoo for the boys.

The first formal PBL case used in this study related to behavior learning theory (Appendix A). Students assumed the role of a recent graduate from a university teacher preparation program who was seeking employment at a private elementary school. Students were asked to respond to the job announcement at the school, which required the applicant to convey and understanding that learning outcomes are observable and measureable responses (e.g., skills, academic, etc.) produced by environmental influences. Students were to apply to the position by creating an instructional plan outlining their educational methodology in a way that supported the school's philosophy.

The second formal PBL case related to cognitive learning theory (Appendix B), and required students to assume the role of a college student, majoring in education, who was interested in becoming an SAT tutor. They were asked to apply to a job posting from a mother of a high school student, which clearly stated that she would be interested in someone who would help her son study and could also help her set up a clear study plan to use in the tutor's absence. The case itself presented the students with subtleties which insinuated students should use a cognitive learning theory lens to solve this problem. For example, the email address was printed as, samnomic7@email.com, referencing the term mnemonic instructional strategies, a wide variety of memory enhancing techniques. Another clue was that the letter stated, "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."

The third formal PBL case related to social constructivist learning theory (Appendix C), and required students to assume the role of the coordinator of a summer camp who is in charge of developing a community outreach program in which all campers would participate. Students were informed that the summer camp had a strong commitment to ensuring that stakeholders of the community are socially aware and are well-educated about the characteristics that contribute to being a good citizen. Students were asked to create a plan for the community outreach program, while considering the underlying principles of the camp.

Information gathering worksheets. Students were provided with an information gathering sheet (see Appendix B; Manente, 2014), when given the PBL case, which served as an aid for planning a solution to the problem and as a reference to ensure that they remained on track when devising their solutions. As part of the study design, students were required to read through and complete the information gathering worksheet when conducting the practice problem and prior to each of the three PBL cases. This was done so that students would have a guide to aid with problem solving strategies, while also learning ways of planning, monitoring, and reasoning.

Concept maps. Concept maps were chosen as a support for student learning because they foster the clarification of new knowledge by presenting it in a visuospatial forum that allows connections, understanding, and explanations to be managed and displayed on an integrated map (Khosa & Volet, 2014). When trying to explain the phenomena in the problem, students discover what they already know about the problem, but they also discover what they do not know or which questions still need to be answered (Gillies & Boyle, 2010).

In an educational setting, concept maps can be a useful tool for assessing where learners are, and can also "serve as the framework for subsumption for new material" (Novak & Gowin, 1984, p. 100-101). Additionally, previous research by Kinchin, Hay, and Adams (2000) demonstrated that concept maps were able to help "optimize the composition of collaborative group structure" to promote conceptual change (p. 186). Ultimately, the fundamental principles underlying concept maps appear to lend themselves well to the structure of a PBL environment, as their use can encourage students to engage in meaningful conversations when developing their maps which could lead to socially shared regulation. By adding concepts maps as an additional component of the PBL assignments in this study, the investigator worked to extend existing research by demonstrating that these visuals could be used by PBL facilitators to provide appropriate scaffolds and promote the collaboration needed to positively impact group regulatory strategies.

Throughout the course, when presented with each case, students were given instructions on how to create a concept map prior to engaging in their individual or group efforts toward the construction of their maps. According to Novak (2010), students can typically be trained on how to develop concept maps in 10-20 minutes. To facilitate this, the instructor modeled how students should construct their map using the concepts related to PBL as noted in the assigned articles on problem-based learning and group learning. The instructor also provided students with a model concept map (see Figure 1) to use when developing their own concept maps.

After the model was distributed to students the instructor reviewed the components of the map to ensure student understanding. For example, the instructor explained that students were to first identify the theory or concept and place it at the center of their map. Second, she explained that students were to identify more specific concepts that relate to the theory, and showed students that these were depicted as nodes in the diagram. Lastly, the instructor explained that students were to connect the concepts with a link in order to demonstrate they understood conceptual relationships, and cross-links to demonstrate relationships across different domains.

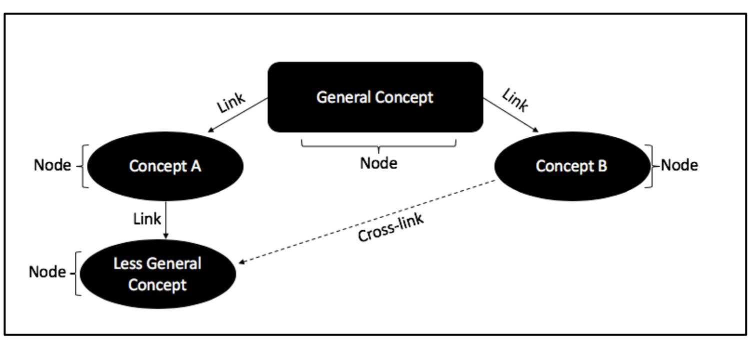

Figure 1: Concept map model. Provided to students at the onset of the developing their own concept-map. Students could reference the concept model throughout all three problem solutions.

Students were then required to make a pre- and post-concept map for each topic of focus during each of the three conditions. The pre-concept map was the first map groups made immediately after reading the case to the problem. This map allowed students to visually represent their knowledge prior to conducting further research. Once students completed their pre-concept map, they began researching concepts associated with the case to solve the problem. While working together in their groups to solve the problems, students were required to develop a new post-concept map, as a group, that depicted knowledge gained from their research. It was hypothesized that this would increase the likelihood of group members engaging in social discourse, which can enhance SSR (Rogat & Linndenbrink-Garcia, 2013). Post-concept maps were submitted once students turned in their final problem solutions.

In addition, the concept maps were used as informal assessments to ensure adequate knowledge gains. Because students submitted two maps, it was possible to compare them to identify any concept gains, as the post-concept maps were expected to be an expanded and more completely linked form of the pre-concept maps. Concept maps are were analyzed by determining concept gains, as depicted in the bar graphs throughout the results section, with the greatest conceptual gains shown by the presence of additional nodes. Sometimes, educators use concept maps for assessment purposes and require no other form of additional assessment (Oliver, 2008; Rice, Ryan & Samson, 1998). However, due to the need to compare the results of this study with Manente (2014), the conceptual gains were not formally assessed in this way. Instead, conceptual gains were identified using the problem solution and comprehension assessments to ensure validity and to determine the effectiveness of concept maps.

Problem solution worksheets. The many components of PBL can be difficult to manage which is why students were provided with a problem solution worksheet which required them to create 3-5 page written solution to the problem during each of the three PBL conditions. The problem solution worksheet served as a model for how students could structure their written solution to the problem. However, students did not have to follow the specific format laid out in the worksheet when creating their response. These worksheets were incorporated and served as a hard scaffold, also known as embedded scaffold, for students when creating their final solution to the problem.

Researchers have pointed out that both PBL and inquiry-based learning share many important characteristics, have treated them synonymously when determining what support and scaffolding is best suited (Hmelo-Silver, Duncan, & Chinn, 2007). In both of these learning environments the instructor presents the learner with a an authentic problem solving task, and requires students to work together throughout when solving the problem, while the teacher takes on the role of a facilitator. The key distinction is that in PBL, is originated in medical education and IL has roots in scientific inquiry. In PBL, students come in contact with authentic content, use problem solving strategies, engage in critical thinking, and practice self-directed learning (Hmelo-Silver, et al., 2007). “In IL, students learn content as well as discipline-specific reasoning skills and practices (often in scientific disciplines) by collaboratively engaging in investigation (Hmelo-Silver et al., 2007, p. 100”. Other researchers who have further examined inquiry-based learning have noted that students in these environments might have difficulties attending to complex information due to a lack of exposure to, competency with, or knowledge of the scientific model being presented (Kress & van Leeuwen, 1996). Therefore, it is important to design scaffolds that provide hints that could help direct students’ attention to key aspects of the model, or in this case, the problem. Prompting questions are a tool that instructors can plan ahead of time and embed into the unit or task to guide student learning and encourage them to explain their findings. For example, in this study, one prompting question asked students "Have you identified and explained the fundamental learning objectives of your plan?" Such questions provide check points for students to reflect on whether they have paid attention to, and comprehend, the key aspects of the topic. To allow for the ability to compare data and identify whether the methods of scaffolding and prompting used in this study contributed to the effects of the group processes, this investigation used the same problem solution worksheets used by Manente (2014).

Comprehension assessments. The instructor formally assessed student learning by using the standardized grading rubric for the written comprehension assessments (see Appendix J, Appendix, K, and Appendix L), which were used by Manente (2014). Comprehension assessments were administered to the students following the completion of each problem solution, and students' scores served as a measure of the acquisition of conceptual knowledge gained from each PBL experience. Each assessment was designed to assess student understanding of each topic (i.e., BLT, CLT, SCLT) and asked students a specific question related to the focus topic. The aim of the assessment was for students to communicate their understanding of the concepts associated with each topic.

Comprehension assessments as an instrument to foster positive interdependence. During the High-Positive Interdependence condition the instructor used a team evaluation approach. This approach required students to complete an individual comprehension assessment for which they received an individual grade that was then averaged with the grades earned by each of their group members. Team members only received the final averaged score, as they were unable to view their individual grades or any of their group members' grades. This form of assessment provides an opportunity to simultaneously maintain individual student accountability and encourage proactive collaboration among peers within small group instruction. It also ensures a balance between an individual group member's need for personal success and the obligation to ensure the success of all other members of the group.

Final exams as a measure of student knowledge. Students were presented with a take-home final examination and in-class final examination, both exams were used and written by Manente (2014). The take-home exam presented was written for the use of another section of an educational psychology taught by Dr. Cindy Hmelo-Silver. The take-home exam presented students with a case which required student to complete an individual written resolution to the problem. The problem presented required students to pretend they were an educational consultant who was asked to provide the school board with an analysis of how they would approach instruction within the district. When solving the dilemma the students were to take the three parent perspectives into account, each parent perspective aligned with the three focus topics presented during the PBL experience. The purpose of the exam was to identify student understanding of the psychological principles presented throughout the 3 focus topics (i.e. BLT, CLT, and SCLT), and provide students with an opportunity to apply this knowledge to an authentic situation.

The in-class exam required students to answer 50- multiple choice questions related to all theories discussed throughout the semester. 27 of the 50 questions related to the three focus topics (i.e. BLT, CLT, and SCLT) that were introduced during the PBL experience. The purpose of the take-home exam was to assess students content understanding of the psychological theories presented throughout the semester.

The role of the facilitator. The instructor facilitated the class to ensure that group members were working together and remaining on task. Facilitation required the instructor to constantly evaluate student learning by checking concept maps throughout the entire PBL process. For example, the instructor asked students to revisit their maps if nodes were not properly linked, or not linked at all. If students were off-task or their maps did not reflect their group discussion, the instructor reminded students to refer to their concept map and convey their expanded knowledge using additional links and nodes. To check for student learning, the instructor asked questions, provided feedback, and asked students to elaborate on their research paths and findings.

The facilitator also remained available to answer any questions students had, monitored the groups, and made sure students were linking their concepts within their concept maps. Errors when linking concepts indicated that students did not understand the relationships between two concepts, and the instructor was responsible for providing additional scaffolds to support learning. For example, one such instance occurred in which Group 1 began to discuss systems of reinforcement and punishment. The instructor listened to the group's conversation and intervened when she heard an incorrect relationship; more specifically, the group attempted to link positive reinforcement and negative punishment when working on the BLT problem. In such a case, the instructor might scaffold by asking one or more students in the group to provide an example of each term, or by asking the students to distinguish between the two forms of punishment and the two forms of reinforcement. However, any such inaccuracies needed to be explained and students were required to discuss these misunderstandings and reference other reliable resources that could help them clarify and solve these problems.

Procedure. On the first day of class the instructor explained the study to the students. Next, students completed a pretest on the three key topics—behavioral learning theory, cognitive learning theory, and social-constructivist learning theory—these scores were then used to determine group formation as described above. At the end of class the teacher instructed students to read three articles on problem-based learning—Newman (2005), Savery (2006), and Johnson & Johnson (1992)—and to reflect on the articles in an online blog through Sakai before the second class meeting.

During the second class meeting, the instructor allotted 45 minutes to address any questions students had about the readings, and also led a short lecture on PBL while modeling how to develop a concept map. When developing the concept map, the instructor explained how it can be used to organize particular concepts in order to demonstrate relationships between the three PBL articles that were assigned. The instructor also distributed a reference key delineating shapes for students to use when developing their own concept maps (see Figure 1).

Research has indicated that students require several practice sessions in order to become acquainted with their new roles in a PBL environment (Torp & Sage, 2002). Thus, following assignment to their PBL groups, students were given a practice problem and provided with an information gathering sheet. Students were required to read the practice problem case and then complete the information gathering sheet as a group. The instructor then lead an open discussion about the information gathering sheet and asked students to share what their groups discussed. Students were then instructed to work with their group to begin creating a concept map of the topic discussed in the article. Afterward, a representative from each group contributed to creating one large concept map on the chalk board. Next, the students were given the problem solution worksheet (see Appendix C, F, & I) and used the remainder of class to work with their groups to devise a solution to the practice problem.

The last 15 minutes of class were used to discuss the problem solutions. Students were asked to discuss their planning process, their prior knowledge concept map (i.e., pre-concept map), their expanded concept map (i.e., post-concept map, which reflected new knowledge gained while solving the problem), and their final problem solution. Students were also debriefed on their perceptions of their PBL experience, and were asked to describe what they did and did not like. Students were encouraged to further expand on the concept map and read an article by Azer (2004), discussing specific characteristics of PBL instruction, prior to the next class meeting. These tasks were assigned in order to ensure students were prepared before facing a graded problem solution. It is highly recommended that students are prepared ahead of time, but it is also important for the instructor to keep in mind that they should not teach the material prior to the presentation of the problem (Torp & Sage, 2002).

PBL-Independent (BLT) condition. The first formal PBL assignment began during the third week of the course and focused on the topic of behavioral learning theory. The assignment consisted of two work sessions—3 hours and 2.5 hours long, respectively—followed by a comprehension assessment for which students earned individual grades. During the first work session, each student was provided with a case (Appendix A), an information gathering worksheet (Appendix B), markers, and a sheet of paper to develop a concept map. Students individually read the case on the topic of behavior learning theory, completed the information gathering worksheet, and developed their pre-concept maps. During this time the instructor walked around the room to support students as needed. Once students completed their information gathering worksheet and their pre-concept map, they were instructed to begin using additional resources (e.g., the course textbook or textbooks used in previous coursework or related to the theories of educational psychology, computer, newspaper articles, etc.) that could help them solve the problem. While working on solving the problem, students were given a second sheet of paper, were instructed to create a new concept map, and could reference their pre-concept map if desired. At the end of the class students submitted all their materials. Outside of class they were permitted to review course material and collect materials that could potentially help with solving the problem, but did not engage in actually writing the problem solution. During the second work session, in the next class, the teacher returned all the materials to the students, and they continued to work on their individual problem solutions and concept maps. The last 30 minutes of the class were reserved for students to complete their individual comprehension assessments on behavior learning theory.

PBL-Positive Interdependence (CLT) condition. In the fifth week of class students were given the second formal PBL assignment which focused on cognitive learning theory (Appendix D). The assignment also consisted of two work sessions—3 hours and 2.5 hours long, respectively—followed by a comprehension assessment for which students earned individual grades. During the first session, students were again provided with a case, an information gathering worksheet and a large sheet of paper. Students were instructed to co-create their pre-concept map with their group members. Groups were provided with paper and markers, and each student was instructed to use a different color marker and indicate which was used somewhere on the map. This format allowed all students to simultaneously manipulate the concept map with the goal of increasing the likelihood of groups engaging in social discourse in order to enhance socially shared regulation (Lee et al., 2014). The joint map also represented the groups' conceptual knowledge of PBL components and concepts (Lee et al., 2014). During this time the instructor walked around the room and checked on the groups to ensure that everyone was participating and that the concept maps were being fully developed. For a concept map to be fully developed the students had to connect all nodes (concepts) with links explaining the relationships.

After completing their group pre-concept maps, students were instructed to conduct research to build on their previous knowledge and then co-create a new map. Students continued to have access to their pre-concept map to reference if so desired. At the end of class students submitted their group concept map to the instructor. The students' materials were returned during the second work session (sixth week of class), and students completed their problem solution and group concept map. The last 30 minutes of the second session were allotted for students to conduct their comprehension assessment on cognitive learning theory.

PBL-High Positive Interdependence (SCLT) condition. During the seventh week of class, students were given the third and final PBL assignment focusing on social constructivist learning theory (Appendix G). The sequence of activities was similar to the second PBL assignment, except that students' individual comprehension assessment scores were averaged with the individual scores that their group members received, this is also known in literature as "Team Assessment" (Manente, 2014).

At the end of the semester students completed an in-class final which consisted of 50-multiple choice questions. The topics on the assessment were covered throughout the entire semester, students had 3 hours to complete the assessment. Students were also required to complete a take-home final, which was used to assess students ability to understand principles and application of psychological theory. After the completion of the finals students were asked to complete a voluntary survey. The survey consisted of several rating scales and open-ended questions related to the various forms of PBL instruction students experienced throughout the course (Appendix O). Analysis of student feedback can be found within the findings.

Table 3

Overview of the PBL Conditions

<table>
<tr><th>PBL Condition</th><th>Topic</th><th>Description of Problem Solution Condition and Scoring</th><th>Materials Completed</th><th>Assessment and Scoring</th></tr>
<tr><td>Independent (PBL-I)</td><td>Behavior Learning Theory (BLT)</td><td>Individually solved a problem presented in a case format, each individual was expected to submit a single problem solution, for an individual grade.</td><td>Each individual was expected to complete and submit the following:
Information Gathering Sheet
Pre-Concept Map
Post-Concept Map
Problem Solution Worksheet</td><td>Each student was given an evaluation, on BLT, which was completed individually, assessed individually, and each student earned an individual grade.</td></tr>
<tr><td>Positive Interdependence (PBL-PI)</td><td>Cognitive Learning Theory (CLT)</td><td rowspan="2">Students worked in small groups to collectively solve a problem presented in a case format, each group was expected to submit a single problem solution, for a shared grade.</td><td rowspan="2">Each small group was expected to collectively complete and submit the following:
Information Gathering Sheet
Pre-Concept Map
Post-Concept Map
Problem Solution Worksheet</td><td>Each student was given an evaluation, on CLT, which was completed individually, assessed individually, and each student earned an individual grade.</td></tr>
<tr><td>High Positive Interdependence (PBL-High P)</td><td>Social Construct-ivist Learning Theory (SCLT)</td><td>Each student was given an evaluation, on SCLT, which was completed individually, assessed individually, but earned a Team Assessment grade.</td></tr>
</table>

Note. Adapted From "Is Collaboration A Necessary Component of Problem-Based Learning?" (Doctoral dissertation). By, C. Manente, 2014 (https://rucore.libraries.rutgers.edu/rutgers-lib/44171/PDF/1/play/). Copyright 2014 by Christopher Manente. Reprinted with permission.

Study 2: Evaluating the Quality of Socially Shared Regulation

Though students are often placed in groups, they do not necessarily engage in socially shared regulation. Research has supported using pedagogical tools, such as task specific prompts and guiding questions, to encourage students to engage in behavior related to the specific components of socially shared regulation (i.e., planning, monitoring, and evaluation) (Azevedeo & Hadwin, 2005). Thus, for this study it was hypothesized that the use of an information gathering sheet and the incorporation of concept mapping would increase the likelihood that students would engage in the components of socially shared regulation.

The goal of the second portion of the current study was to use qualitative analysis to further examine the two PBL group conditions—PBL-Positive Interdependence and PBL-High-Positive Interdependence—to determine if the sub-processes of socially shared regulation (i.e., planning, monitoring, evaluation, and behavior regulation), socioemotional interactions (positive and negative), and collaborative interactions (i.e., collaborative and non-collaborative) can be identified. The qualitative analysis expands on existing literature by offering a more in-depth investigation of the social interactions that occurred in the four groups while students were solving the problem solutions. Thus, the same students who volunteered to take part in the first portion of study were used for this second portion of the study (N=16).

Results

The analysis of the problem solutions, comprehension assessments, take-home final, and in-class final encompassed the quantitative portion of the investigation. The research team, which consisted of the principal investigator and trained student, coded all data using a set of scoring rubrics following each of the problem solutions, the comprehension assessments, and the take home final. In addition, the team used qualitative methods to further understand the quality of socially shared regulation that took place during the two conditions which required students to work in groups. Lastly, a mixed methods approach was used to explain how the concept maps could possibly link to the performance outcomes on task and assessment performance, as well as how concept maps could be used to foster SSR.

Coding Reliability

The first analysis that took place used Cohen's Kappa with linear weighting (1968). The purpose of the Cohen's Kappa statistic (with linear weighting or otherwise) is to measure the degree to which two graders agree on the grades they have assigned across a series of work specimens. Often it tests using a categorical grading scheme—such as letter grades A, B, C, D, F or Pass/ Fail or Excellent/ Good/ Poor. In typical applications of the kappa statistic, N cases each provide one work specimen that is graded by Grader 1 and Grader 2. In this data set, while each of the cases (i.e., each student) has provided numerous work specimens with each involving slightly different instructional content obtained under a different treatment condition. These different tasks and different treatment conditions do not necessarily matter; what matters is how the two graders have responded to them. Cohen's kappa (with linear weighting or otherwise) provides a numerical index of how well the scorers agree with each other. This data also provides a numerical index of how well the scorers agreed with each other. In this situation, there are three separate values of kappa with linear weighting, one for each of the three tests conducted—comprehension assessments, problem solutions, and take-home finals. Inter-scorer agreement was calculated separately for each of the three conditions and an explanation of each analysis has been provided below (Cohen, 1968).

Statistical Analysis

The analysis began with an SPSS (Version 23.0) crosstabs analysis. This analysis was used simply to count how many times Grader 1 and Grader 2 agreed and how many times they disagreed when scoring the problem solutions and comprehension assessments. Because SPSS calculates unweighted kappa, additional software was needed to calculate linear weighted kappa. As a result, the SPSS cross tabulations were input into the Vassarstats program (Lowry, 2001 – 2018).

Inter-Scorer Reliability for Comprehension Assessments and Problem Solutions

The analysis started with a cross tabulation of ratings obtained from Grader 1 and Grader 2. The results of the cross tabulations analysis for comprehension assessments are shown in Appendix P1 and the results for the problem solutions are shown in Appendix Q1. The cross tabulations served as input to Lowry's Kappa Calculator, and a summary for each calculation of kappa with linear weighting can be found in Appendix P2 for comprehension assessments and Appendix Q2 for problem solutions. An analysis of the inter scorer reliability on the comprehension assessment in the current study produced a value for Cohen's Kappa=.80. An analysis for inter scorer reliability for the problem solutions in the current study produced a value for Cohen's Kappa=.79. When using Viera and Garret's (2005)'s standards for understanding weighted kappa (Table 4), one can see that both of these values can be interpreted as demonstrating "substantial agreement" between the scorers' data. Ancillary output which summarized the frequency of agreement—maximum possible, expected by chance, and observed—can be found in Appendix P3 and Appendix Q3. Finally, Appendix P4 and Appendix Q4 summarize proportions of agreement—maximum possible, expected by chance, and observed. Table 5 provides a summary of the degree agreement observed across comprehension assessments and problem solutions between scorers.

Table 4

Interpretation of Kappa

	Poor	Slight	Fair	Moderate	Substantial	Almost Perfect
Kappa	0.0	.20	.40	.60	.80	1.0

Note. From "Is Collaboration A Necessary Component of Problem-Based Learning?" (Doctoral dissertation). By, C. Manente, 2014 (https://rucore.libraries.rutgers.edu/rutgers-lib/44171/PDF/1/play/). Copyright 2014 by Christopher Manente. Reprinted with permission.

Table 5

Degree of Agreement Between Graders Observed Across Methods of Evaluation

Data Source	Total # of Scores	Agreement due to Chance	Frequency of Agreement	Weighted Kappa
Comprehension Assessments	*183*	*46.34*	*140*	*.80*
Problem Solutions	*86*	*22.24*	*69*	*.79*

Inter-Scorer Reliability for Finals

Appendix R shows the results of the cross tabulations of grader ratings for the final exam. However, two key factors prevented the possibility of using this data to calculate kappa and measure inter-scorer reliability for the final assessment: (a) a relatively large number of score categories (i.e., 10 for each grader) and (b) different score categories used by each grader (i.e., categories 6, 10, and 15 only used by Grader 1 and categories 8, 21, and 23 only used by Grader 2). It would be possible to revise the table and add rows for categories 8, 21, 23 and columns for categories 6, 10, and 15; however, doing so would create a 13 x 13 table. Such a large table would far exceed the limitations of any kappa calculators (e.g., the kappa calculator used above allows a maximum of eight categories). This option would also require the inclusion of a substantial number of zeros which would interfere with accurate calculations.

The primary investigator chose to add the graders' scores across a series of problems included in the Final assessment to get a total score for each student. These item scores represent what Likert (1932 as cited in Warmbrod, 2014) referred to as *summative response* data, or data derived by adding or averaging ratings across several items to obtain a total scale score. There has been debate in the literature about what scale of measurement this kind of data provides. Allen and Yen (1979) assert that the data are only ordinal, or able to determine rank of students from highest to lowest performance, because there is no way to demonstrate that equal score differences (e.g., the difference between scores in the data of 10 and 12 or between 14 and 16) correspond to equal differences in the attribute being scored (e.g., the student's knowledge or proficiency). Others have argued, however, that just as one cannot prove that equal score differences correspond to equal attribute differences, it is also the case that one cannot prove that equal score differences do not correspond to equal attribute differences, thus leaving it up to the researcher to decide what to believe (Ghiselli, Campbell, & Zedeck, 1981). Meyers, Gamst, and Guarino (2006) have summed up the argument this way:

> The vast majority of research published in the behavioral and social sciences over the past half century or more have used summative response scales as though they met interval properties… In our view, this treatment of summative response scales is acceptable, appropriate, and quite useful (p. 23)

Given this, it can be assumed that the data provides a reasonably good approximation of an interval scale of measurement. As such, this researcher totaled the ratings given to the individual items in the final assessment to get a total score for each student. While there are a number of choices of statistical test that could be run given this data, the interclass correlation (e.g., Pearson correlation) is typically used and is considered more appropriate when there are more than two raters involved.

The Pearson correlation was also used because it is readily interpretable by a wide audience. The Pearson correlation between the two graders' scores on the final assessment was extremely strong, $r(46) = .966$, $p < .001$ (2-tail), indicating a very close agreement between the raters. One criticism of the Pearson correlation as a measure of inter-scorer agreement is that it evaluates the degree to which two graders' scores co-vary, but is insensitive to differences in score magnitude between the raters. For instance, both of the following sets of numbers would yield the same perfect inter-scorer reliability correlation, i.e., $r = 1$:

Table 5

Degree of Agreement Between Graders Observed Across Methods of Evaluation

Grader1	Grader2	Grader1	Grader2
5	5	5	7
2	2	2	4
7	7	7	9
1	1	1	3
8	8	8	10

Both sets of data produce the same perfect correlation despite the fact that the two graders in the second set did not actually "agree" perfectly because Grader 2 is two points higher than Grader 1 on all the scores. To evaluate this possibility, the mean scores were calculated and compared using a *t*-test in order to determine if there were differences in the score magnitude of the two graders. The mean of the scores from Grader 1 was 19.40 (*SD=4.12*) and the mean of the scores from Grader 2 was 19.08 (SD=4.05). Levene's test for equality of variances was nonsignificant, F(1,94)= 0.001, *p*=.978, indicating virtually no difference in the variability of scores assigned by the two graders. The *t*-test was also non-significant, *t* (94) = 0.375, *p* = .709 (2-tail), indicating virtually no difference in score magnitudes from the two graders. In sum, the two graders showed extremely good agreement on the final assessment.

Statistical Analysis of One-Way Planned Comparisons

In order to further examine the significance of variance between the three levels of the independent variable, *instructional design*, an ANOVA and *a-posteriori* comparisons were conducted for each source of data in the study. The analysis was conducted to examine the influence of the nuisance variable *position/topic*. *Position* refers to the order in which each condition was presented, and *topic* refers to the key topic that was targeted.

In these analyses with three levels, there can only be two comparisons (i.e., to compare every condition with every other condition). These are called *a-posteriori* or *post hoc* comparisons, as opposed to planned or *a-priori* comparisons which only look at a few of the possible comparisons in a data set. Thus, for the purposes of this study a-posteriori comparisons were used because comparing all conditions with each other was indicated.

Coding for Comprehension Assessments

A scoring rubric, which corresponded with the topics of the course, was used to determine the complexity of response on the comprehension assessments. Using the rubric the primary investigator and research assistant scored responses related to the four primary concepts (i.e., concept 1, concept 2, concept 3, concept 4) for each of the three topics (i.e., topic 1, topic 2, topic 3) using an ordinal scale of six levels. For each primary concept a student identified in their response, a score was assigned in order to denote the complexity of the student's explanation based on the scale outlined in Table 1. The coding levels were cumulative, for example, in order for a response to be scored as meeting a level six, the response needed to have met level 1-5.

Statistical Analysis of Comprehension Assessment (CA) Scores

Descriptive statistics were run initially, and 95% confidence intervals for Comprehension Assessment scores for Behavioral Learning Theory (BLT), Cognitive Learning Theory (CLT), and Social Constructivist Learning Theory (SCLT) can be seen in Appendix S1. A within-subjects one-way ANOVA was then used to evaluate the overall significance of differences between the levels of the independent variable. This procedure makes a number of statistical assumptions, including sphericity (i.e., that the distribution variances are approximately equal and that there are no strong differences between correlations involving the various pairs of variables) and that the dependent variables are normally distributed. The normality of each distribution was evaluated both visually, by inspecting the frequency histograms shown in Appendix S2, and statistically, by calculating measures of skewness and kurtosis. With only 16 cases in the analysis, it is difficult for a distribution to achieve normality, but all three distributions were at least somewhat bell-shaped. Measures of skewness and kurtosis for each distribution, found in Appendix S2, were compared with the benchmark values of ±1.0 suggested by Meyers, Gamst, and Guarino (2006) to identify extremely non-normal distributions. Only CSCLT exceeded these values (skewness = -1.335; kurtosis = 1.087) with substantial negative skewness and leptokurtosis. Violation of the normality assumption can distort the shape of the sampling distribution of the F statistic and result in distorted reported significance levels. With this in mind, a more stringent level of significance ($p < .001$) was used in evaluating the significance of the obtained value of F. The assumption of sphericity was tested using Mauchley's test of sphericity, and the result was not statistically significant, Mauchley's W = 0.843, $\chi^2(2) = 2.397$, $p = .302$. Given this, the sphericity assumption was considered met in evaluating the F test. The ANOVA F test revealed a strong and statistically significant effect of the independent variable, $F(2, 30) = 15.904$, $p < .001$, partial □^{2} = .515.

Post Hoc Comparisons. Post-hoc comparisons were used to explore sources of the significant effect. A Bonferroni correction was used to adjust the reported significance levels so as to set the Type I error rate for the collection of comparisons at $\alpha = .05$. The results of these comparisons are shown in Appendix S3. All levels of the independent variable were found to differ significantly from each other.

Table 6

Comprehension Assessment Scores

Instruction	Mean	Std. Error	95% Confidence Interval	
			Lower	Upper
PBL-Independent	15.38	.67	13.94	16.81
PBL- PI	19.25	.68	17.78	20.72
PBL- High PI	20	.84	18.26	21.86

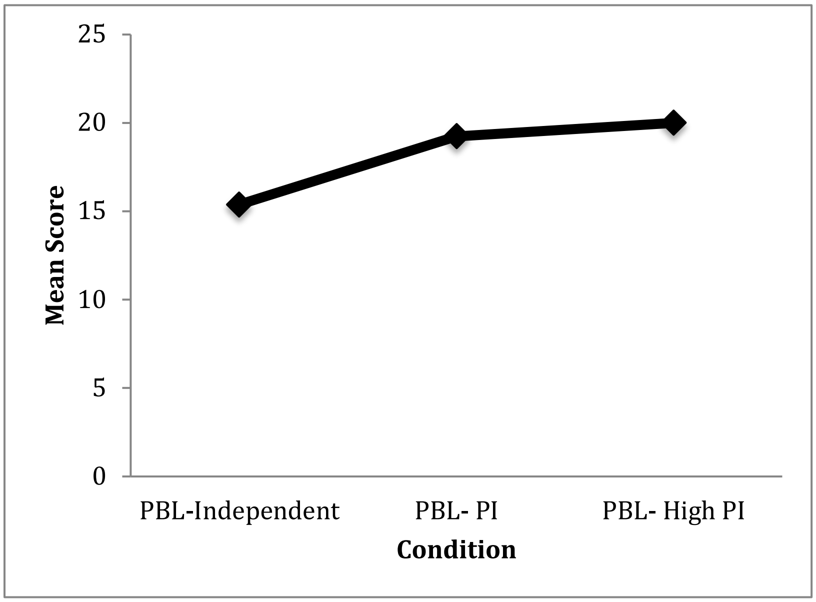

Figure 2: Means of comprehension assessment scores across the three PBL conditions

Statistical Analysis Problem Solution (PS) Scores

Descriptive Statistics. Descriptive statistics and 95% confidence intervals for Problem Solution scores for Behavior Learning Theory (BLT), Cognitive Learning Theory (CLT), and Social Constructivist Learning Theory (SCLT) are provided in Appendix T1.

Within-Subjects (Repeated-Measures) One-Way ANOVA. A within-subjects (repeated-measures) one-way ANOVA was used to evaluate the overall significance of differences between the levels of the independent variable. The normality of each distribution was evaluated both visually, by inspecting the frequency histograms shown in Appendix T2, and statistically, by calculating measures of skewness and kurtosis. With only 16 cases in the analysis, it is difficult for a distribution to achieve normality, but both BLT and CLT were somewhat bell-shaped. Measures of skewness and kurtosis for these two variables (shown in

Appendix T2) Table 3) were also less than the $\pm$1.0 benchmark value used to evaluate substantial deviations from normality. However, the third variable, PSCLT, was markedly bi-modal positively skewed (skewness = 1.180). Given this violation of the normality assumption, a more stringent level of significance ($p < .01$) was used in evaluating the significance of the obtained value of F. The assumption of sphericity was tested using Mauchley's test of sphericity, and was found to be statistically significant, Mauchley's W = 0.119, $\chi^2(2) = 29.826$, $p < .001$, indicating a violation of the sphericity assumption. Because violation of the sphericity assumption can distort reported levels of significance, the Greenhouse-Giesser corrected F test was used to evaluate the overall significance of the treatment effect (Meyers, et al., 2006). Even with this more conservative test, there was a strong and statistically significant effect of the independent variable, $F(1.063, 15.947) = 29.493$, $p < .001$, partial $\square^2 = .663$.

Post Hoc Comparisons Post-hoc comparisons were used to explore sources of the significant effect. A Bonferroni correction was used to adjust the reported significance levels so as to set the Type I error rate for the collection of comparisons at $\alpha = .05$. The results of these comparisons are shown in Appendix T3. All levels of the independent variable were found to differ significantly from each other.

Table 7

Problem Solution Scores

Instruction	Mean	Std. Error	95% Confidence Interval	
			Lower	Upper
PBL-Independent	14.78	.82	13.04	16.52
PBL- PI	17.63	.23	17.13	18.12
PBL- High PI	20.38	.32	19.63	21.06

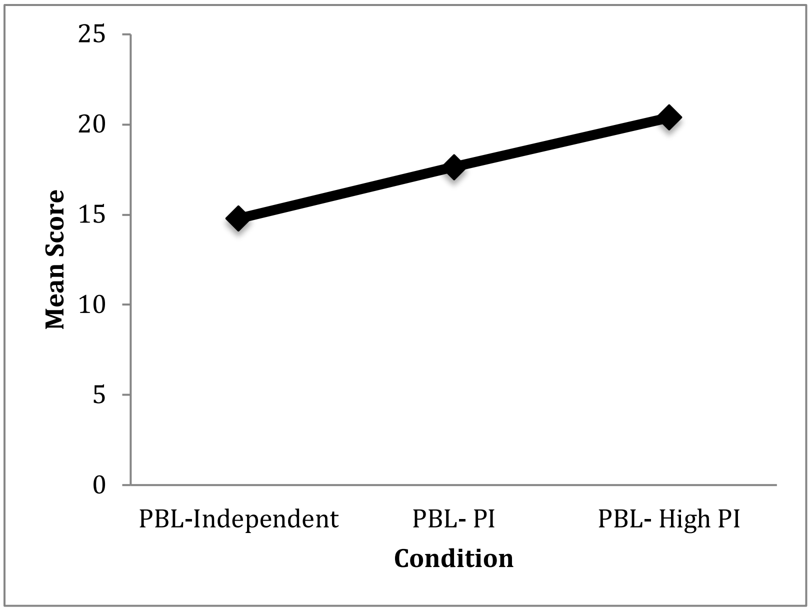

Figure 3: Means of problem solution scores across the three PBL conditions

Take Home Final Scores

Descriptive Statistics. Descriptive statistics and 95% confidence intervals for Take Home Final scores CBLT, CCLT, and CSCLT are provided in Appendix U1.

Within-Subjects (Repeated-Measures) One-Way ANOVA. A within-subjects (repeated-measures) one-way ANOVA was used to evaluate the overall significance of differences between the levels of the independent variable. The normality of each distribution was evaluated both visually, by inspecting the frequency histograms shown in Appendix U2 and statistically by calculating measures of skewness and kurtosis. With only 16 cases in the analysis, it is difficult for a distribution to achieve normality, and both the frequency histograms shown in Appendix U2 and the measures of skewness provided in Appendix U1 indicated that all three variables were negatively skewed. However, only the variable CSCLT produced measures of skewness (-1.414) and kurtosis (1.590) that exceeded the benchmark values for identifying strongly non-normal distributions. Given this violation of the normality assumption, a more stringent level of significance ($p < .01$) was used in evaluating the significance of the obtained value of *F*. The assumption of sphericity was tested using Mauchley's test of sphericity, and was not significant, Mauchley's W = 0.932, $\chi^2(2) = 0.991$, $p = .609$. As such, the *F* test was evaluated without a non-sphericity correction. Results of the one-way ANOVA indicated no significant treatment effect, $F(2, 30) = 0.591$, $p = .560$, partial □^{2} = .038.

Post Hoc Comparisons In the absence of a significant ANOVA *F* test there was no statistical justification for performing post hoc pairwise comparisons. It was concluded that there were no significant differences between levels of the independent variable, instructional format (i.e. PBL- condition).

Table 8

Take Home Final Scores

Instruction	Mean	Std. Error	95% Confidence Interval	
			Lower	Upper
PBL-Independent	18.79	.80	12.00	23.50
PBL- PI	19.81	.97	17.74	21.88
PBL- High PI	19.13	1.26	16.44	21.82

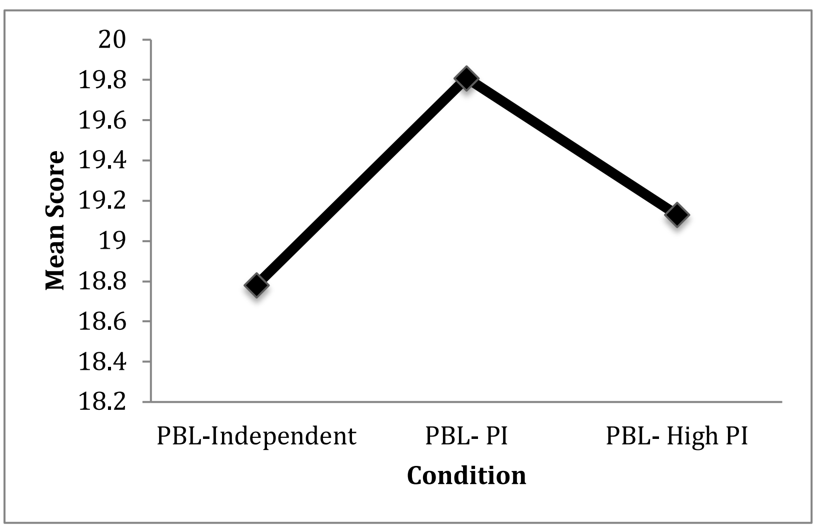

Figure 4: Means of take home final scores across the three PBL conditions.

In-Class Final Scores

Descriptive Statistics. Descriptive statistics and 95% confidence intervals for In-Class Final Exam scores CBLT, CCLT, CSCLT, and Total scores are provided in Appendix V1.

Within-Subjects (Repeated-Measures) One-Way ANOVA. A within-subjects (repeated-measures) one-way ANOVA was used to evaluate the overall significance of differences between the levels of the independent variable. It should be noted that although descriptive statistics are provided in Appendix V2 for In-Class Final Exam Total scores, the one-way ANOVA compared only three measures: In-Class Final Exam CBLT, CCLT, and CSCLT scores. Total scores were not included in the ANOVA because these scores were formed by summing scores on CBLT, CCLT, and CSCLT and, as a result, contained no unique information. The normality of each distribution was evaluated both visually, by inspecting the frequency histograms shown in Appendix V2, and statistically, by calculating measures of skewness and kurtosis. With only 16 cases in the analysis, it is difficult for a distribution to achieve normality, but all three distributions were at least somewhat bell-shaped. None of the distributions exceeded the ± 1.0 benchmark indicative of excessive skewness, but CBLT was excessively leptokurtic (kurtosis = 1.223) and CCLT was excessively platykurtic (kurtosis = -1.275). Given these violations of the normality assumption, a more stringent level of significance ($p < .01$) was used in evaluating the obtained value of F. The assumption of sphericity was tested using Mauchley's test of sphericity, and the test was not significant, Mauchley's W = 0.875, $\chi^2(2) = 1.866$, $p = .393$. As such, the ANOVA F test was evaluated without a non-sphericity correction. Results of that ANOVA revealed a strong and statistically significant effect of the independent variable, $F(2, 30) = 26.228$, $p < .001$, partial □^{2} = .636.

Post Hoc Comparisons. Post-hoc comparisons were used to explore sources of the significant effect. A Bonferroni adjustment was used to adjust the reported significance levels so as to set the Type I error rate for the collection of comparisons at $\alpha = .05$. The results of these comparisons are shown in Appendix V3. All levels of the independent variable were found to differ significantly from each other.

Table 9

In-Class Final Scores

Instruction	Mean	Std. Error	95% Confidence Interval	
			Lower	Upper
PBL-Independent	5.00	.20	4.57	5.44
PBL- PI	8.01	.35	7.32	8.80
PBL- High PI	7.63	.30	6.98	8.27

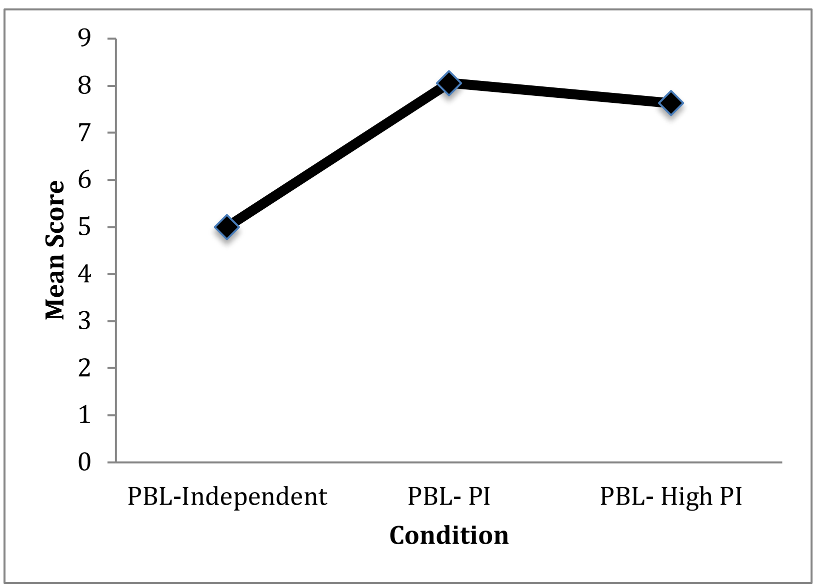

Figure 5: Means of in-class final scores across the three PBL conditions

Comparison of Study Findings

In order to further understand if concept maps aided in the increase in scores on the comprehension assessments, mean scores from this study were compared to mean scores from Manente's (2014) study. Given the similarities in design between the two studies, it is reasonable to use Manente's (2014) results as a control group reflecting student performance on the PBL tasks without the use of concept maps. Witchtel-Myles' role as the research assistant on Manente's study, and her access to the same course and university population, allowed for consistency in study design and implementation; as well as in instruction and scoring. Part of the consistency in implementation involved ensuring equivalency across the participants in both studies, particularly as it pertained to prior knowledge of the focus topics and the division of that knowledge across groups prior to engaging in PBL. As described above, students in the current study were given pre-tests that were scored according to a grading rubric (Table 1). Students were then assigned students to groups such that the overall total scores of each group were equal and reflected that each group had the same degree of prior knowledge of all concepts among the members.

This was modeled directly after the method used in Manente (2014), in which students were given a pretest and their scores were then used to create groups. In Manente's study, only 10 of the 50 participants (20%) demonstrated a "justified" level of prior knowledge, or a score of 4 or higher on one of the focus topics. This meant that their score was considered high enough to warrant assigning them to a certain group. The remainder of the participants were grouped randomly because their scores did not reach this level, and therefore were not considered high enough to impact the overall level of prior knowledge in any one group.

As a result of this procedure, members in both studies were assigned with a focus on evenly distributing knowledge across groups. Additionally, none of the students in the current study scored a 4 or above on any of the focus topics. This indicates that overall, the groups in this study had an equivalent, or lower, level of initial prior knowledge compared the groups in Manente (2014). This gives further support to the idea that any higher scores for students in the current study, when compared to scores for students in Manente (2014), are likely due to the use of concept maps, rather than due to the current students having a greater degree of knowledge than Manente's.

The difference in means for PBL-Independent is 2.49, the difference in means for PBL-PI is 2.05, and the difference in means for PBL- High PI is 1.5. Figure 6 provides a visual comparison of the CA means from Manente's (2014) study and the current study. It is demonstrated here that that those students who used concept maps scored higher on their comprehension assessments than those students who did not use concept maps.

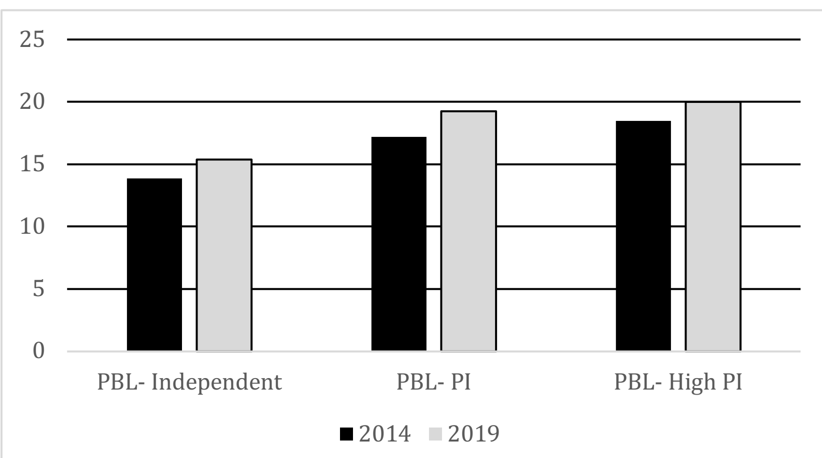

Figure 6: Comparison of Comprehension Assessment Scores Across Manente's 2014 Study and Wichtel-Myles' 2019 Study

Mean of scores for each problem solution in Manente's (2014) was calculated and displayed in his results using a cumulative approach, in addition he used a two-tier system when grading the problem solutions. The first tier, was graded using the same scoring sheet (see Table 1) that was used for the comprehension assessments. The second tier, aimed to identify the quality of the student's response by rating the students response on 5 dimensions using the 3-point scale that was on the rubric. The dimensions included assessing: the theme of the response, application to theory, response to address the problem, practically of the plan, and clarity of writing. The researcher noted that two graders identified the quality of the student response, and when doing each scorer wrote notes to justify their numerical scores for each category, an overall mean score was assigned, the scorers checked their rankings to resolve any discrepancies, and came to 100% agreement, before identifying an overall mean score. Following this process the scorers ranked the groups to determine an overall mean score, this was meant to provide identification of the quality of the problem solution response.

Identification of the scores for each tier were not depicted in the graphs or tables, nor was this data presented anywhere within the study write-up. Therefore, this scoring system was not incorporated into the analyses of the problem solutions for this study, because it would be impossible to compare student scores across conditions and forms of assessment (i.e. the problem solutions, comprehension assessments, and the take-home final). Also, the ability to thoroughly analyze findings from the problem solution using the two-tiered system in order to compare them with Manente's would also be impossible. Therefore, the mean scores from Manente's and the current study cannot be displayed for the purpose of comparing mean scores. However, it should be noted that findings from Manente's (2014) study indicated that PBL-PI was greater than the scores earned for PBL-High PI. Whereas findings for the current study's problem solutions indicate that students scored better during PBL-High PI.

Analysis of Concept Maps

In order to answer research question 1b, "Do conceptual gains produced on a concept map effect performance?" the research team had to identify concept gains attained by each group. Qualitative analysis was used to assess the concept maps created by the groups, and required both graders to analyze the physical maps made by the students. The first condition (Independent-PBL), which required students to explore behavior learning theory, was not scored for the purposes of this analysis because this study is looking to determine if concept maps impacted the quality of SSR and served as a scaffold for students during group work. Therefore, a total of 16 maps were analyzed: 4 pre-concept maps for cognitive learning theory, 4 post-concept maps for cognitive learning theory, 4 pre-concept maps for social constructivist learning theory, and 4 post-concept maps for cognitive learning theory.

First, concept maps were scored to determine if the concepts depicted on the concept map were accurate. To do this, both scorers reviewed the maps and came to 100% agreement as to what was accurate and what was inaccurate. For a concept to be accurate, the concept had to associate with the focus topic. Once all concepts that were displayed on each groups' pre-concept and post-concept maps were scored and the scorers came to 100% agreement, the number of accurate concept were then graphed. The research team then subtracted the total number of accurate concepts on the second concept map from the first concept map; with the difference representing the total number of concept gains each group made.

Groups completed the concept map in different ways, with some using specific examples from the case, including examples from the concepts associated with cognitive learning, or incorporating specific solutions to the problem in theirs. Many of the solutions demonstrated each group's ability to apply the concepts to a real-world problem, which is one of the primary goals of PBL. The groups depicted their solutions in nodes, or the concepts depicted via circles on the map, and these were also scored as accurate concepts (see example of concept map and the components of a concept map in the Methods section Figure 1).

Concept links and crosslinks were not scored; however, accurate uses of crosslinks were noted throughout the findings description of each group. Crosslinks are visual links between concepts in different domains, or levels, of the concept-map; and provide a visual way of seeing how concepts are related to one another (Nova & Cañas, 2006). An example of a crosslink can be seen in Group 3's post-concept map of social constructivism (Appendix CC). Crosslinks should not be confused with concept links. For example, Group 1 used a concept link which could be misinterpreted as a crosslink in their pre-concept map of cognitive learning theory when they drew a link between association and behavioral learning theory. This is not a crosslink because the two concepts share the same level of hierarchy.

High Positive Interdependence Condition: Social Constructivist Theory. When analyzing the maps constructed by students during the high positive interdependence condition Group 1 made the least concept gains (concept gain=0; See Appendix AA). When constructing their first map they identified "social learning theory" as the main concept under focus, and "social constructivism" as a concept associated with this theory. The pre-concept map made reference to three theorists (i.e., Piaget, Bandura, and Vygotsky) and theories, as well as concepts closely associated with social constructivism and social learning theory, these were all scored as accurate. Their revised map focused on social constructivism, as they omitted social learning theory from their map. The revised map included practical concepts associated with social constructivism such as scaffolding and channeling, these were all scored as accurate as well. While this group did not produce as many concept gains in comparison to their peers, their revised map does make it apparent that they became more knowledgeable of concepts and practices of social constructivism by making it apparent they were able to specific concepts associated with social constructivism.

Group 2 made 10 concept gains. Group 2's pre-concept map on social constructivist learning theory was accurate. When constructing their revised map the group did note *internalization* as a concept associated with scaffolding. However, this was a concept that the instructor identified as a misconception when the students were working on the problem solution. The instructor provided support to students to clarify their understanding of the purpose of scaffolding, and the group did not reference the term internalization in their final problem solution.

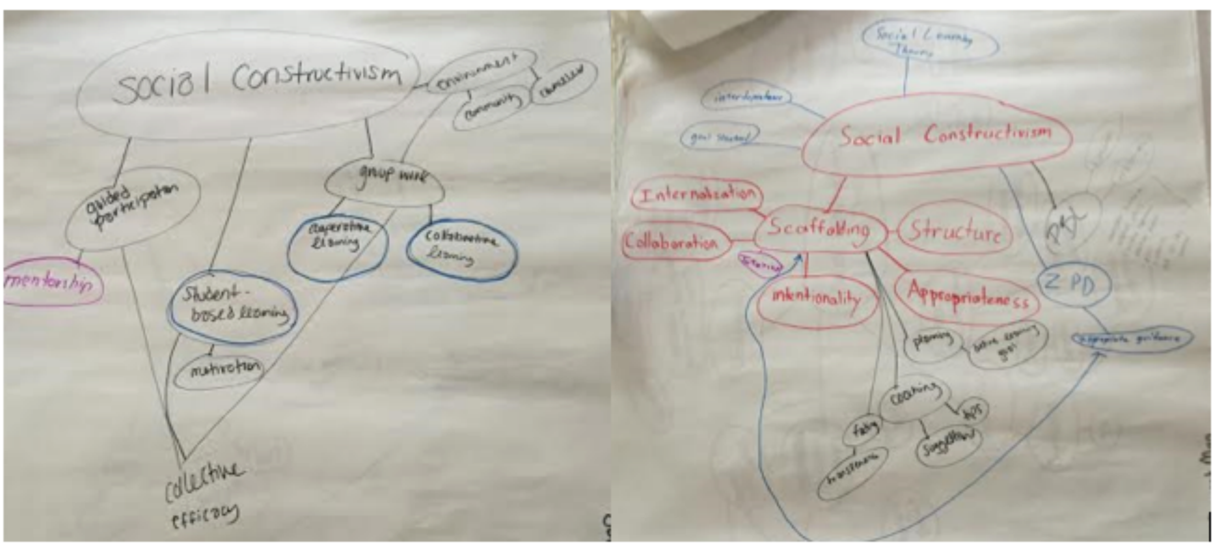

Figure 7: Group 2, Social Constructivist Learning Theory Pre- (left) and Post- (right) Concept Map

Group 3 made 26 concept gains, which was the most of any group. Group 3's pre-concept map inaccurately associated the term "fixedness" with social constructivism. When working on the problem solution the group identified this inaccuracy and recognized that it was actually a concept associated with cognitive learning theory. This group's post-concept map was 100%

accurate. While crosslinks were not scored, because many groups did not accurately use them, it should be noted that this group did accurately use crosslinks in their post-concept map to make connections across different hierarchies.

Group 4 made 9 concept gains. Their pre-concept map incorrectly identified social learning theory as the main concept, and depicted a total of 4 concepts: social learning theory, zone of proximal development, collaborative learning, and cooperative learning. These concepts are all associated with social constructivism, therefore their nodes were scored as 100% accurate. However, this group did not follow instructions and, before the instructor was able to correct them, added two concepts “different levels” and “same level” onto their map after referencing an online resource. These two concepts were not scored as part of their initial map or depicted in their revised map, therefore they were omitted from all scoring. Group 4’s revised map correctly recognized social constructivism as the overall theory. They also accurately linked the zone of proximal development with the theorist Vygotsky. This group also incorporated social interaction as a concept and accurately linked cooperative learning, but did not include collaborative learning which had been included in their previous map. Lastly, they depicted “scaffolder” and accurately linked concepts associated with the practice of scaffolding.

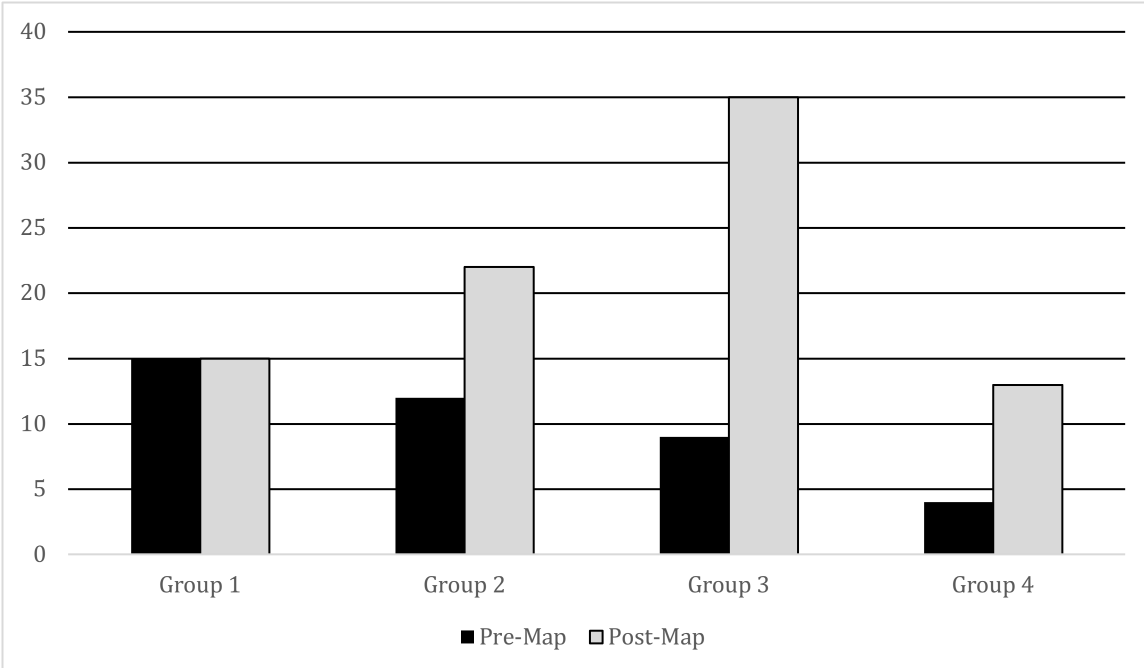

Figure 8: Social Constructivist Learning Theory node gains for each group

Positive Interdependence: Cognitive Learning Theory Group 1 made 3 concept gains. Group 1's pre-concept map incorrectly identified memory as the main theory rather than cognitive learning theory. Additionally, while the group depicted several concepts on their map that were associated with cognitive learning theory, the students incorporated concepts that were previously discussed in the class. During the creation of the post-concept map the instructor ensured that the students were aware that the concepts had been discussed, and that, while they should be working to understand how all of the theories and concepts could be integrated, they were to be using the lens of cognitive theory for that particular task. This group's revised map focused primarily on the accurate concepts associated with cognitive learning theory such as the information processing model, and they did not include any other learning theories (e.g., behavior learning theory or Bloom's Taxonomy).

Group 2's pre-concept map had several accurate nodes; however, one node was not scored as it included "monotonicity" which was not relevant to the learning theories previously discussed or cognitive learning theory. While there did not ultimately appear to be many conceptual gains for this group (conceptual gains=4), their post-concept map was very detailed and included the various types of memory (i.e., procedural, declarative, semantic, and episodic) and also provided a specific example to go along with each memory type.

Group 3 demonstrated the most concept gains (concept gains=68) on their post-concept map. Though it appeared as if this group used crosslinks to demonstrate relationships among concepts, the links could not be categorized as crosslinks because they were referencing relationships across the same hierarchy. The instructor asked this group of students if they had conducted additional research outside of the classroom, and the group did admitted to conducting research in between class meetings. This group did thoroughly discuss their out of class findings to ensure everyone was up-to-date with the newly found information pertinent to solving the problem solution.

Group 4 had a total of 10 concept gains. Group 4 incorrectly used their pre-concept map to outline their study schedule for the student in the problem. Before providing this group with the sheet of paper for the post-concept map the instructor reminded them that their concept map could include information of theories and concepts, and links could be extended from those concepts to represent examples of application. Group 4's post concept map did not include such a schedule and included concepts associated with cognitive learning theory.

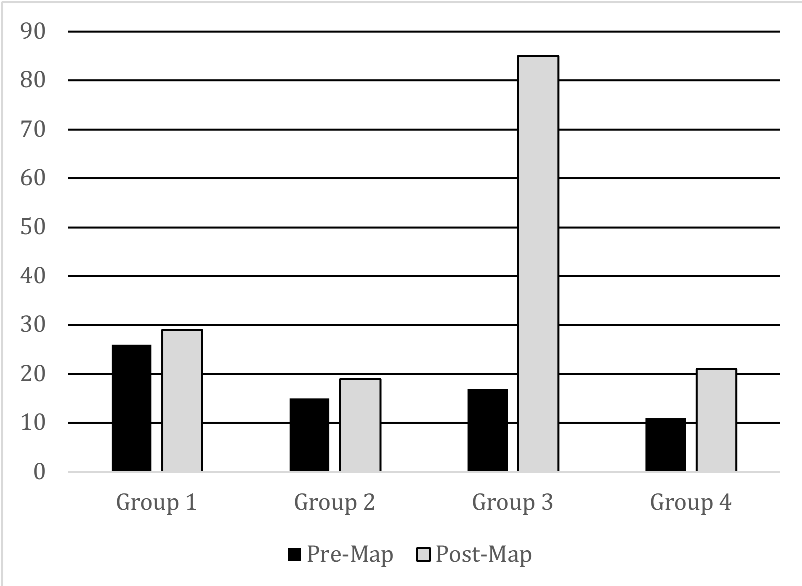

Figure 9: Cognitive Learning Theory node gains for each group

Qualitative Analysis of Socially Shared Regulatory Processes

Qualitative analysis was used to determine 1) which socially shared regulatory processes occurred when students engaged in PBL, 2) if the use of concept maps aided in student performance when completing the problem solving tasks, and 3) which condition of PBL, if any, is best suited to foster high-quality SSR. The first step of data analysis required transcription of the video/voice recordings into Dedoose software. After all the video/ voice recordings are converted to text format in Dedoose, the researcher wrote memos and developed a qualitative codebook. This required breaking the text into segments, which were then coded into categories (Gall, Gall, & Borge, 2010). These codes and categories were defined using Rogat and Linnenbrink-Garcia (2013)'s categorization of the processes associated with regulation (i.e., planning, monitoring, and behavioral engagement), social emotional interactions (i.e., positive and negative), and collaborative interactions (i.e., collaborative and non-collaborative). It is important to note that there were instances in which discussions or comments were coded more than once. For example, if a student comment was coded an “task planning” it might have also been coded as “content planning”.

Rogat and Linnenbrink-Garcia (2013) asserted that in order to fully understand socially shared regulatory processes, the quality variation in each of the regulatory processes needs to be taken into account. To identify the quality of socially shared regulation the codes and categories were defined using Rogat and Linnenbrink-Garcia’s (2013) descriptions of the levels of quality in SSR (see Table 10). More specifically the researcher used the codes: high quality planning, low-quality planning, high-quality monitoring, low-quality monitoring, high-quality behavioral engagement, and low-quality behavioral engagement (Rogat & Linnenbrink-Garcia, 2013, p.388, Table 3).

Table 10

Description of Primary Codes and Subcodes presented by Rogat and Linnenbrink-Garcia (2013)

SSR	Description	
	High Quality	Low Quality
Task Planning	1. Any instance in which an individual in the group (or the group collaboratively); a. Interprets the case instructions or prompt on the information gathering sheet accurately. b. Establishes a plan or goals (sub goals and end goals), that can be used by the group to solve the problem. c. Revisits and/or references the instruction, plan, and/or goals to ensure the group is adhering. d. Designates responsibilities to members of the group.	1. Any instance in which an individual of the group (or the group as a whole) a. Inaccurately reads, references, fails to interpret the case instructions, or prompt on the information gathering sheet. b. Does not discuss, or make a plan, or create goals (sub- and end goals). c. Any instance in which two or more group members are working on the same task, as a result of lack of communication, which results in redundant work product.
Content Planning	1. Any instance in which an individual in the group (or the group collaboratively); a. Provides task-relevant content knowledge to contribute insightful group task work. b. Proposes a rational for content plan. c. Accepts and integrates individual group members' recommendations into the group product (i.e., information gathering sheet, problem solution, concept map).	2. Any instance in which an individual of the group (or the group as a whole); a. Provides inaccurate rationales. b. Is "unresponsive to group member's content plan."
Content Monitoring	1. Any instance in which an individual member in the group (or group as a whole) a. monitored accurate use of educational theorists, theories, concepts, and/or principles; b. With analysis, comparison, reasoning, application and/or provides supporting evidence to an idea. c. By questioning members' comments for clarification and elaboration. d. Any instance in which an individual (or the group as a whole); e. Checks whether the group met all the goals. f. Checks the use of theorist, theories, concepts and principles. g. Corrects grammar or spelling of a product of the group's related to the problem solution (i.e. information gathering worksheet, concept map, problem solution).	1. Any instance in which an individual member of the group (or group as a whole); a. Focuses on monitoring the accurate answer. b. Is "unresponsive to provided content monitoring." c. Does not provide feedback or further explanation. d. Shows "harsh or highly critical monitoring."
Monitoring of the Plan	1. Any instance in which a group member (or group as a whole) referred to the case description, instructions on the information gathering sheet, or the concept map to: a. Clarify the task b. Identify the next steps. c. Modify the plan	1. Any instance in which a group member (or the group as a whole); a. Did not revisit the plan which lead to incomplete tasks. b. Relied on teacher monitoring of the plan or prompting to complete the information gathering sheet or concept map.
Monitoring Progress	1. Any instance in which a group member (or group as a whole); a. Checks the time, verifies the progress of the sub-goals and goals, and/or group productivity. b. Checks to assess all guiding questions on the information gathering sheet to ensure all questions are answered. c. Checks to assess all nodes and links are accurate and complete on the concept map. d. Checks or assesses the problem solution to ensure all tasks are complete.	1. Any instance in which a group member (or group as a whole); a. Heavily focused on pace and time remaining.
Behavioral Engage-ment	1. Any instance in which a group member (or group as a whole); a. Suggested to involve group members in the task. b. Recommended collaborating on the designated task.	1. Any instance in which a group member (or group as a whole); a. Used brief reminders or cues. b. Used a negative tone in an attempt to re-engage a peer. c. Ignored off task behavior.

Collaborat-ive Interactions	1. Two or more members of the group interact by sharing ideas and working jointly when problem solving.	
Non-Collaborative Interactions	1. Individuals work on separate portions of the task at the same time or by passing around the task for each group member to complete sequentially.	
Positive Socioemotional Interactions	1. Group interactions that support and encourage harmonious group functioning. Which include: active listening and respect, inclusion, and group cohesion.	
Negative Socioemotional Interactions	1. Group interactions that undermine harmonious group functioning. Which include: discouraging participation, disrespect, and ow group cohesion.	

Adapted from, Rogat and Linnenbrink-Garcia's (2013) Study Rogat & Linnenbrink-Garcia, 2013, p.388, Table 3

Results of the Quality of Socially Shared Regulation Analysis Qualitative analysis was used to help determine which PBL condition was best suited to foster high-quality SSR. According to Rogat and Linndenbrink-Garcia (2013),

> …the quality of socially shared regulation involves 6 components: (1) a group's sustained focus on content monitoring, that is (2) synergistically facilitated by frequent and effective behavior regulation strategies and efficient planning, (3) as well as content planning that evokes relevant prior knowledge, content, and strategies, and (4) whose plans and monitoring are justified with rationales grounded in content understanding. Moreover, socially shared regulation is (5) responsive and respectful of all group members and (6) is collaborative… (p.113).

The quality of each occurrence of socially shared interaction was evaluated using Rogat and Linndenbrink-Garcia's (2011; 2013) elaborated definitions, adapted versions of which can be found in Table #. Using these definitions, the primary researcher and research assistant reviewed the conversations to identify both high and low quality variations of the occurrences of each regulatory sub-process—planning (task planning and content planning), monitoring (content monitoring, plan monitoring, and progress monitoring), and behavioral engagement.

Planning. Two types of planning were observed in the groups: task planning and content planning. A description of the types of planning observed, and an analysis of the variation in quality across all four groups, will be discussed below.

Task Planning. Task planning was defined as any instance in which an individual, or a group, discussed or interpreted directions (Rogat & Linnenbrink-Garcia, 2011). All groups exhibited task planning during each of the three tasks (i.e., information gathering sheet, concept map, and problem solution) throughout each of the two group problems presented (i.e., SCLT and CLT). This type of planning was seen immediately after a student read the case aloud, as well as while some groups were developing their concept maps. The most prevalent examples of task planning occurred when students read the prompts on the information gathering sheet—specifically, question 5 (i.e., "Where will you look to find any additional information that you need?") and question 6 (i.e., "Use the following space to draft an outline related to how you plan to address the identified problem"). These two questions prompted group discussion on how members would approach solving the problem. Task planning also involved the discussion of specific goals or sub-goals that were established by the group.

High quality task planning was defined as instances in which a group collaboratively engaged in this activity. For example, all groups exhibited high quality task planning after reading the last case which focused on the topic of social constructivism. More specifically, all four groups had a group member read the case out loud and the group then discussed the case instructions to make sure all members understood what the camp was trying to promote. Instances of low quality task planning were exhibited when groups were solving the second case which focused on the topic of cognitive learning theory. During PBL-PI Group 2, Group 3, and Group 4 had a member read the case relevant to CLT out loud, but the groups then moved on to discussing the chapters they thought were relevant rather than thoroughly discussing the case instructions to ensure group understanding. Group 1 was the only group that did ensure all group members understood the instructions.

Another common example of task planning occurred when, after reading the case, students in each group determined the sequence in which they would tackle each question presented in the case. Those groups demonstrating high quality task planning created a shared plan and were able to begin work, reference their plan, and easily monitor their progress along the way. In this instance, Group 2 did not create a shared plan during PBL-PI, as one member of the group began researching without discussing the case or group goals with the rest of the group. As a result the member began to research a concept that was inaccurate, which interfered with group progress and resulted in low quality task planning. There was also another instance in which, when first introduced to the problem, a member of Group 2 and a member of Group 4 kept quietly to themselves and did not actively engage in discussion related to the plan associated with PBL-PI. Once the members from Group 2 and Group 4 had access to outside resources, and were more comfortable with the content, they were able to become more active in group discussions related to the plan.

While most instances of task planning occurred at the onset of the problem solving process, there were instances in which groups exhibited task planning at the beginning of the second session of each problem solution. During this time groups either revisited the plan, engaged in task monitoring, or created a new plan based on their progress from the previous session. High quality task planning also occurred frequently at the end of the first session and at the beginning of the second session of each of the problem solutions, during which times students would discuss how they would proceed to solve the problem. Conversely, low quality task planning occurred halfway through the problem solving process in instances where groups designated assigned roles to individual group members. Interestingly, Groups 2, 3, and 4 all exhibited instances of low quality task planning during PBL-PI. In these cases the groups often did not fully agree on task roles, resulting in group members completing the same task. Groups 3 and 4 did have a group discussion about their findings and thoroughly discussed ways to incorporate contributions of two group members that were assigned the same task. Unlike Group 3 and Group 4, Group 2 did not discuss findings in order to incorporate both group members efforts to contribute to the group product, in fact, members decided to utilize one of group member's contributions without reviewing both findings as a group to intermix the individual group members' contributions into an overall group finding. This resulted in low-behavioral engagement.

Content Planning. Content planning referred to any instance of a group member, or group as a whole, outlining or organizing theorist names, theories, or concepts associated with the particular theoretical topic (Rogat & Linnenbrink-Garcia, 2011). High quality content planning occurred when group members shared accurate information associated with the theorist, theory, or concepts; and engaged in thoughtful discussion between group members. Thoughtful discussion included group members elaborating on peer knowledge, the use of rationale to incorporate such knowledge into the group's product, and the incorporation of group members conceptual thoughts and conceptual applications into the task work. Low quality content planning occurred when group members exhibited little discussion about theorist, theories, and concepts; or did not acknowledge group members' ideas or incorporate them into the working product.

Instances of content planning occurred during both the PBL-PI and PBL-High P; however, instances of high quality content planning did not occur until the second session of both problem solutions. Content planning was exhibited by all groups, as the concept map seemed to support content planning throughout all problem solutions. For example, all groups exhibited content planning when they would note a particular concept on their concept maps and then discuss examples of its application. A common instance of high quality content planning occurred when discussing the various types of memory (i.e., sensory, episodic, etc.). Group 2 initially discussed examples of each type that did not necessarily relate to the problem solution; however, after the group discussed these real-world applications, they identified an additional example which applied to the solution of the problem. They ultimately discussed how they would integrate the last example it into their final write up, and also depicted these examples in their concept map. Group 3 demonstrated high quality content planning when constructing their map by drawing a crosslink to connect two concepts, and then discussing the concepts' relation and how they would incorporate them into their written problem solution during the High-P condition. As discussed earlier, there was an instance in which Group 2 divided up tasks and added concepts to the map without further discussion, resulting in low-quality task and content planning during the PBL-PI condition. Group members also completed the same tasks twice because the plan was not fully understood by the group members. Group 4 discussed their findings and it resulted in high content planning because they were able to integrate their ideas to develop a large schema for both problems; whereas Group 2 and 4 divided tasks which resulted in low-quality content planning. Instances of low quality content planning also occurred during both PBL-PI and PBL-High P when group members were not familiar with the topic while constructing their pre-concept maps and elaborated discussion did not occur. However, when groups revisited these concepts after accessing additional resources, it promoted high quality content planning because group members elaborated on the previously discussed concepts, and discussed rationales for why these concepts should be incorporated into their content plans.

Monitoring. Three types of monitoring occurred: content monitoring, plan monitoring, and progress monitoring. Each will be described and examples from all four groups will be further discussed to examine the variation in quality between the groups.

Content Monitoring. Content monitoring referred to a group exhibiting the ability to assess their accuracy with the content throughout a task. High quality content monitoring occurred when students revisited their post-concept map and made connections between concepts and how they related to the problem solution. Groups 1, 3 and 4, exhibited in depth discussions of concepts they would place on both the pre-and post-concept maps associated with SCLT. All groups referenced their maps in group discussion to ensure concepts depicted on the pre-concept map were relevant to the topic of discussion, and all groups collaboratively determined what items should be included on their post-concept map and ensured concepts depicted on the map were included in the final write-up. Group 3 demonstrated instances of high content monitoring, not all the items placed on their post-concept map during PBL- PI and PBL-High P were included in their write up. Because they had a total of 68 conceptual gains during PBL-PI and 26 conceptual gains during PLB-High P, the group discussed and debated which items should be prioritized as thoughtful and deliberate inclusions in their solution and in their final write-up.

It is important to note that high quality content monitoring was demonstrated by all groups during the second session of PBL-High P. During this time group members examined their final problem solution and determined if the content presented in their solution was appropriate for solving the case and application. All group members ensured that their fellow group members understood the concepts associated with social constructivist learning theory that had been discussed throughout the problem solution. Instances of high quality content monitoring also occurred when solving the problem. For example, there were instances in which members of Group 4 split up the work and wrote on previously designated topics. After writing, members read their sections on the topic aloud to the group, and the group provided feedback regarding the individual write-ups. A few group members provided lengthy feedback, and highlighted evidence from the text to support their recommended changes. The group then worked together to come up with a revised draft of the concept write-ups and integrated all group members' ideas.

Instances of low quality content monitoring occurred when group members were focused on finding the right answer rather than on ensuring conceptual understanding. Both Groups 2 and 3 exhibited high quality and low quality content monitoring during the second PBL-High P condition. Groups 2 and 3 created their pre-concept map and, rather than discussing which items to include on the map, some group members would write a concept down before discussing with the group. When creating the post-concept map group members did tend to discuss concepts before placing them on the map; however, instances in which some group members wrote before discussing did occur and were modified after they were discussed by the group.

Instances of low-quality content monitoring were evident during PBL-PI when individuals made a recommendation without providing any further explanation or elaboration, or failed to provide an example of application from theory to practice. Additionally, instances in which group members made changes or switched tasks without providing additional input or feedback to explain their changes were also considered low quality content monitoring. This occurred with Group 3. Though these revisions may have resulted in more accurate group product, the interactions were considered low quality because the lack of feedback meant that group members' misconceptions were not remedied. Low quality content monitoring also occurred with Group 2 when a group member did not equally contribute to the process of group monitoring—whether because certain members were considered "in charge" of the group or because one member ignored another member's monitoring efforts.

Plan monitoring. Plan monitoring occurred when a group exhibited the ability to revisit their plan to ensure they were meeting their goals and sub-goals. High quality plan monitoring occurred when the group would revisit the group plan to ensure that they were working on the correct step, or to clarify any misconceptions they had about the current plan. Planned monitoring was infrequent across all groups throughout both PBL-High P and PBL- PI. Plan monitoring occurred in the second session of each problem solution for both PBL-High P and PBL-PI, at which point groups worked to ensure that all members knew where they left off and what steps they were take that class meeting. This occurred more frequently during PBL-High P. Low quality plan monitoring occurred when the primary investigator had to initiate group monitoring. For example, there were instances during PBL-PI, in which the primary investigator would ask members from Group 2 what steps they were taking and if those steps aligned with the group's original plan. Though the groups were prompted to engage in high quality plan monitoring in these instances, they were not categorized as high quality planning since the groups did not initiate the process. Group 1 did an excellent job of developing a study plan for Charlie, but this could be because their concept map incorporated pieces of their plan they referred to and discussed during the write-up.

Progress monitoring. Progress monitoring occurred when groups recognized accomplishments, identified what remained to be completed, and ensured that they were working efficiently by monitoring the time. For example, Group 4 exhibited moderately-low quality progress monitoring during PBL-High P by delegating small jobs for short intervals of time. They would give their team members opportunities to conduct research on a designated concept for no more than 10 minutes then reconvene and relay what they found to the group by sharing ideas and discussing the topic thoroughly. Sometimes more than one individual would conduct research on the same topic to ensure through understanding. After discussing the research findings, the group would determine if further research needed to be conducted. If they needed to find more information about the topic they would do so, but before doing so they would determine, based on time, if research should be done by one or two people. If there was a lot of time left often it would be done by one person, if time was limited then two individuals would conduct research._

Group 1 and Group 3 exhibited high quality monitoring progress by ensuring that they were staying on pace and maintaining awareness of how much time remained to make sure they completed the tasks within the time allocated during PBL-PI and PBL-High P. While monitoring time allowed some groups to work effectively, other groups who monitored time became distracted, focused less on understanding the content, and demonstrated low quality progress monitoring as a result. For example, there was an instance in which Group 2 rushed to complete the problem during PBL-High P and, in doing so, one individual took on the responsibility rather than ensuring that the other group members understood how they were going to incorporate a particular concept into their problem solution. Progress monitoring was more apparent during PBL-High P condition, this was because all groups had to ensure everyone knew the material for the comprehension assessment. Multiple groups discussed how much they had to accomplish and how much time they had to review as a group before sitting down for the comprehension assessment.

Behavioral Engagement. Behavioral engagement occurred when individuals used various strategies to encourage their group members to be actively involved in the group product. High quality behavioral engagement involved instances in which members asked conceptual questions to keep each other engaged with, or to help refocus on, the task. All four groups exhibited high quality behavioral engagement strategies to ensure their peers were remaining on-task. For example, if a member from Group 1 noticed another group member disengaged often they would ask them a question in order to gain their perspective on the discussion topic. Low quality behavioral engagement occurred when students simply encouraged other group members to remain focused and stay on task, but did not do anything to prompt a reconnection to the material. Other instances of low level behavioral engagement occurred when a group member would ask a disengaged member a close-ended question which could be answered with a one-word response rather than in a way that required the member to be an active participant in the group. There were also instances in which Group 3 did not encourage an off-task, non-participating group member to engage in group work during PBL-PI. In these cases members ignored the peer, and the other team members took on more work as a result. During the PBL-High P condition this group did ensure that everyone was equally contributing towards the group product, and assigned each member particular tasks to aid in this.

While the high-interdependence condition was designed to prevent a situation in which group members did not equally contribute from occurring, there were instances in which it still did. For example, in one instance Group 2's members did not encourage a disengaged member to participate in working on the problem solution. Instead, they waited until the end of the problem solution and then one member worked to ensure that everyone, including the disengaged member, had a conceptual understanding of the topic because they knew that the assessment grades would all be averaged together.

Quality of Socially Shared Regulation

To answer the question 2A, "What kind of SSR processes are exhibited by students working on PBL activities?" the primary investigator and research assistant conducted a qualitative discourse analysis to further explore the meaning behind these social interactions in relation to the quality of SSR across the groups. To do this the scoring team collaboratively ranked the group's quality of SSRL based on the coded processes that have been discussed. After analysis it was concluded that Group 1 exhibited the highest quality of SSRL, while Group 2 exhibited the lowest. Taking a closer look at both groups can aid in identifying what processes were exhibited during these PBL tasks, as well as offer the opportunity to identify some targets for future research which could address ways to support learners to ensure high quality SSR is achieved during PBL.

Group 1 maintained high quality social regulation, which supported group productivity and a focus on content monitoring and understanding. Group 1 began to work on the tasks by engaging in high quality task planning, content planning, and progress monitoring. Upon receiving the PBL case, the group read the case out loud. Once the group read the case, members thoroughly reviewed the case to identify concepts, questions that the case was proposing, and theoretical applications of which they had previous knowledge that would aid in addressing the problem (i.e., content planning). Members collaboratively discussed the questions to ensure everyone knew what the questions were asking, and they used the information gathering sheet to devise an answer to each question after through discussion (i.e., task planning). They worked together to understand the directions in order to devise a plan, and kept track of their progress along the way. Collaborative planning and shared plan monitoring helped Group 1 avoid many of the pitfalls other groups faced. Group 1 quickly caught mistakes while following directions, and planned efficiently so that they were able to devote a majority of time and regulatory resources to the task and monitoring understanding. The strategy of monitoring progress also proved effective for this group. However, the group's behavioral engagement was variable, as members exhibited instances of low-level reminders to stay on task by other group members, as well as higher quality instances aimed at redirecting members to certain aspects of the task (e.g. "hey can you check something in the textbook for me?").

Group 1 had sustained positive socioemotional interactions, with infrequent negative interactions that were mild and quickly resolved if they occurred. The positive interactions were especially helpful in encouraging monitoring and collaboration (e.g., "I don't understand the differences between the concepts you are talking about, can you explain?"), which prompted the group to consider the identified concern and monitor task work rather than engaging in put-downs or other negative interactions. This group also appeared committed to ensuring that all members understood the tasks, as evidenced by increased monitoring of each other's understanding and working to make sure that all members were included in the task work. Additionally, this group was adamant about making a plan and adhering to it; and, rather than criticizing off-task behavior, members encouraged each other to remain on task. These positive socioemotional interactions helped facilitate behavioral engagement.

Group 2 exhibited the most instances of low-quality socially shared regulation (i.e., low task planning, content planning, and monitoring of the plan). During the first group problem solution (PBL-PI) they exhibited instances of low-task planning as they failed to establish a plan as a group. The instructor had to encourage the group to complete their information gathering sheet and to work together. They also needed additional support from the instructor to use the pre-concept map to identify known concepts and establish a baseline sense of the topics of which the group as a whole was aware prior to conducting research. When solving the problem, the instructor also had to provide reminders for the group to reference their information gathering sheet to ensure they were monitoring the plan they initially set up (e.g. "Are you guys referring to question 6 on the Information Gathering worksheet?". During the PBL-High P condition, the instructor had to encourage Group 2 to elaborate their responses to the information gathering sheet, because they shared the belief that they "did not have to write everything down." Also, during both problem solutions there were instances in which this group exhibited low behavioral engagement and non-collaborative behaviors. For example, one group member did not contribute equal effort during PBL-PI, and fellow group members did not encourage the member to contribute. Instead, they remained quiet and kept to themselves. Despite this, the group did display some instances of behavioral engagement during the second group problem there were instances. For example, during the PBL-High P group members encouraged the member's participation by assigning more specific tasks (e.g. "can the two of you look up social learning theory while we look up social constructivist learning theory along with the theorists?"). Though this increased the student's participation, the group did not acknowledge all the contributions which resulted in low-socioemotional interactions overall.

Relationship between SSR, Problem Solution Scores, and Assessment Scores

Group 1 had the highest mean score for both problem solutions which included a social component (PBL-PI and PBL-High P), and the highest quality of SSR. This group had the lowest conceptual gains for both PBL-PI and PBL- High P; however, their maps communicated that they revised their understanding of the theories accurately and they provided concepts that were more closely associated with practical theoretical concepts. This group exhibited high quality task planning by ensuring each group member understood the instructions prior to both PBL-PI and PBL-High P, and used their information gathering sheet as a tool to help develop a plan for their problem solution. Despite their low conceptual gains, this group did engage in positive socioemotional strategies (i.e., active listening and waited for the group members to share their thoughts, acknowledged their group members thoughts on the concepts, and then shared their own ideas on the concepts) during group discussion and adjusted their map to include agreed upon information that was deeper than what was initially depicted on their pre-concept map. This group also listened to each of its group member's contributions and provided many instances in which they praised their groupmates for their contributions (e.g. "Thank you for explaining the differences between declarative and procedural memory.").

Group 4 had the highest take-home final and in-class final scores, and the quality of SSR was ranked moderate-high. Group 4 also had the highest mean average of comprehension assessment scores for SCLT. They exhibited instances of high quality SSR processes throughout both problem solutions; however, high quality SSR was only sustained through PBL-High P and not during PBL-PI. During the first problem solution, task planning was low as the group initially did not work together to establish a plan. During the second group PBL (i.e., PBL-High P) they did ensure a plan was in place prior to beginning the task. The quality of content monitoring for the first problem solution was somewhat moderate in the beginning but increased during the second class meeting of the first group problem solution. During the second problem solution this group exhibited high quality content monitoring throughout the task. Also during the PBL-PI there were members that did not contribute to the group's pre-concept map. Additionally, positive socioemotional strategies were not always evident, as there were instances in which they did not include all group member's contributions to the group product. During PBL-High P these strategies to engage others were adjusted and the group listened to all group member contributions.

Group 3 had the highest comprehension assessment score for cognitive learning theory (PBL-PI), and behavior learning theory (PBL-I). This group also had the most conceptual gains on both concept maps. Overall this group exhibited moderate-low SSR. More specifically this group did exhibit instances of low quality task planning during PBL-PI and low behavioral engagement. Interestingly this group exhibited instances of very high quality content planning and instances of low quality content planning, which resulted in low group cohesion and instances of collaborative and non-collaborative interactions. Instances of low content monitoring occurred when group members placed concepts on the concept map without group discussion; while instances of low-group cohesion and non-collaboration occurred when groups were conducting research on concepts associated with solving the problem. During the second problem solution Group 2 continued to exhibit instances of low behavioral engagement, but there were instances in which they positively encouraged group members to contribute to the group product.

Group 2 had the highest score for the problem solution on behavior learning theory (PBL-I), but the lowest score on the corresponding comprehension assessment. The group also exhibited instances of low-task planning, content planning, monitoring the plan and low behavior engagement. The instructor had to encourage them to create a plan, and suggested that they reference their information gathering sheet and concept map throughout solving the problem. Lastly, there were instances in which group members were not involved or encouraged to contribute to group discussion. Further analysis of possible factors that contributed to these results I provided in the discussion section of this paper**.**

Analysis of Student Feedback

Many researchers use feedback from their subjects to assess their experimental designs. In the case of this study, student feedback served the dual purpose of helping evaluate the course structure as well as the experimental design. Student perceptions of the learning design, based on past and recent learning experiences, have an important influence on the learning strategies they use and impact the quality of their learning outcomes (Fry, et al., 1999). Therefore, it is important for instructors, and in this case researchers, to understand these perceptions, particularly for the purpose of identifying ways to improve the learning and experimental designs in the future.

Students were provided with a voluntary survey that was distributed immediately after the in-class examination on the last day of the educational psychology course. The survey consisted of several rating scales and open-ended questions related to the various forms of PBL instruction students experienced throughout the course. A total of 12 students agreed to provide feedback, and the primary investigator left the room while surveys were completed. Students' answers remained anonymous.

Students had an opportunity to rate the various forms of scaffolding that were available throughout the PBL experience (e.g., information gathering sheet, question prompts presented on the problem solution worksheet, the use of concept maps, the teacher as a facilitator) on a scale of 1(not very helpful) to 5 (very helpful). Students rated the concept maps and the teacher as equally the most helpful methods of scaffolding (3.8 average rating), the information gathering sheet (3.5 average rating), and problem solution prompts as the least helpful (2.67 average rating). When given the opportunity to write about their thoughts, students reported that the concept maps were crucial to the learning experience because they facilitated communication and highlighted important concepts that may have typically been missed or forgotten about in an unrecorded conversation. While the maps were considered useful in learning the PBL process overall, some students did note that they would have liked the opportunity to use their own system or organization once they became familiar with PBL.

Four major themes emerged from the students' responses about the PBL experience. One key theme was that students were uncomfortable with PBL when it was first introduced, but became more comfortable as their familiarity with the procedures increased. Another theme was that, though some students continued to prefer individual over group work, they consistently communicated an appreciation for the benefits gained from PBL group work. One such benefit that they identified was the opportunity to expand their own thinking and to approach problems in novel ways when working with peers. A third theme was that students found instructor scaffolding both helpful and necessary, as it encouraged them to think more deeply about certain concepts and topics. Lastly, students expressed an interest in using PBL in their teaching practices in the future, but also reported feeling that they would need more training on how to effectively implement it in their own classrooms.

Discussion

Group work provides many educational benefits, and by understanding the group processes that help support socially shared regulation, educators can determine how to better support their learners in PBL. By using the guidelines on the scaffolding framework presented by Belland, Kim, and Hannafin’s (2013) and social interdependence theory, this study sought to improve on motivation and cognition, to extend on previous research conduct by Manente (2014) and Rogat and Linnenbrink-Garcia (2011; 2013), and determine whether incorporating concept maps into PBL task would improve student performance and increase the frequency and quality of SSR. The study was designed to explore three primary research questions: 1) do concept maps serve as an adequate structure to scaffold student development of skills related PBL, 2) what PBL instructional designs provide opportunities for students to engage in SSR, and 3) to what degree do concept maps affect the quality of SSR exhibited within small group work; as well as six follow-up questions discussed below.

In order to explore the research questions, many supports were put in place with the aim of assisting learners during the three PBL conditions. Each support was carefully and intentionally selected for its applicability to one or more aspects of Belland et al.’s (2013) scaffolding framework; as such, the practice problem, the case itself, the information gathering sheet, the problem solution worksheet and concept maps were all important to ultimate student outcomes. However, it should be noted that some of the selected materials represented more than one guideline within the framework, rather than being applied in an isolated way. A brief description of how each guideline was considered is provided below.

The problem was presented to the students in the form of a real-world case that students might encounter in the future in order to foster interest, establish task value, and promote autonomy. The case was also presented in an open-ended way, which provided opportunities for students to self-direct their own learning by making choices that would contribute to the solution of their problem. The information gathering sheet, problem solution sheet, and concept maps were included to promote mastery goals, belongingness, and expectancy for success. Each item was created to generate focused feedback from the instructor and peers, in order to ensure that students were pushing each other for further understanding as they encountered new concepts and worked to apply them to real world settings. Belongingness was fostered by ensuring students used the concept maps to display their group understanding of concepts associated with each focus topic. Additionally, the placement of concepts on the maps was intended to encourage group members to discuss the concepts, assess personal understanding, and use this information to negotiate shared understanding in order to construct solutions to the problems. Lastly, in order to promote expectancy for success, students were presented with a practice problem before they engaged in the three graded problem solutions so that they could see that the task was achievable.

Results supported the effectiveness of this structure, and ultimately demonstrated that concept maps can be used by instructors to provide scaffolding techniques that foster student understanding during PBL. Additionally, this study demonstrated that concept maps can serve as a shared medium which fosters thoughtful discussion among students during the problem solving process, and, in turn, can lead to compelling problem solutions and increased comprehension assessment scores. Finally, this study went beyond describing scaffolding processes and direct PBL outcomes, and demonstrated that the use of concept maps influences the interrelationship between SSRL processes, instructional strategies, and instructional design to impact the quality of SSR exhibited by groups during PBL.

This chapter will discuss a) prominent findings from the data in response to the research questions and existing literature, b) ways that this study contributes to the existing literature, c) implications for practice, d) ways that future research might continue to build on these findings, and e) limitations of this study.

Intervention Outcomes

Concept maps as a PBL scaffold. In short, concept maps do serve as a structure through which instructors can scaffold the development of skills related to PBL, because they allow student to visually share ideas, discuss the ideas with their collaborative peers, adjust their own thinking, and work in collaboration with group members to devise an agreed upon solution. Their use also allows the instructor to provide targeted scaffolding through reviewing group maps and listening to group discussion. In order to explore this question deeper, it is imperative that we have fully answered the sub-questions that are associated with Question 1.

Impact of concept maps on task and assessment performance. One research question explored whether the use of concept maps impacts individual and group task and assessment performance. Outcomes of this investigation demonstrated that the use of concept maps does support student learning during the problem solving process, and also has a positive impact on students' assessment outcomes. This study found that when groups participated in the PBL-High PI they had higher problem solution scores than in the PBL-PI condition, and performed best on comprehension assessments during the PBL-High PI condition as well. This is partially inconsistent with Manente's (2014) results which found that students had higher problem solution scores during PBL-PI than in PBL-High PI; however, he also found that students had higher comprehension assessment scores in PBL-High PI than in PBL-PI. In both studies, however, students in the positive interdependence conditions performed better than students in the individual PBL condition.

Problem solution scores. It should be noted that it is not possible to directly compare the mean problem solution scores from this study to Manente's (2014) study, because he used two scoring rubrics—the scoring rubric used in this study (see Figure 10) and an additional rubric that assessed the quality of the written problem solutions. Manente combined the scores of both rubrics to calculate a total grade; however, information identifying how scores were allocated was not available. Nevertheless, while the mean scores cannot be compared because, an additional number was factored into Manente's average.

Manente attributed his results to the impact of cognitive load on learners when they engage in PBL. He stated, "as the quality of collaboration increases, cognitive load also increases" (2014, p.102). In other words, he proposed that students had lower problem solution scores in the PBL-High PI condition because the increased demands of a higher level of collaboration resulted in mental strain that ultimately caused students to perform more poorly. Cognitive load theory assumes a limited capacity for working memory which consists of subcomponents that deal with auditory, verbal, and visual information (Sweller, 1994). Cognitive load theory also posits unlimited long-term storage for schemas that vary in their degree of automation (Sweller, 1994). Educators who accept cognitive load theory take into consideration guidelines that aim to minimize extraneous cognitive load by assisting in the presentation of information to ensure students can focus on the content and the acquisition of knowledge (Sweller, 1994). The results of this study may have differed from Manente's (2014) because the inclusion of concept maps provided enough support during the PBL-High PI condition that students were able to continue to improve despite the increase in cognitive load. The lower scores during the first problem solution (PBL-I) are also worth noting, as the requirements of learning how to use concept maps may have effectively produced too much cognitive load for one individual to handle.

Comprehension assessment scores. For this study, results indicated that students performed better on the comprehension assessment in the PBL-High PI condition compared to the PBL-PI condition, and that both collaborative conditions resulted in higher scores than the PBL-I condition. These results were consistent with Manente's (2014) results, and indicate that some type of collaborative component is necessary for PBL to be most effective. It was also possible to directly compare the assessment means across both studies, as the same grading rubric and procedure were used. This comparison demonstrated that comprehension assessment scores for all three conditions in the current study were higher than the respective mean for each condition in Manente's (2014) study. This supports the idea that the use of concept maps can help to improve student performance during PBL.

Take home final scores. Students in the current study scored higher on their take home final exam, across all 3 conditions, when compared to respective participant scores in Manente (2014). This finding also lends support to the value of concept maps in increasing student learning during PBL. The researcher does acknowledge that while the use of concept maps is one apparent differentiating factor which could account for the differences between studies, other factors do exist. For example, the course material was taught by a different instructor and different scorers. However, it is important to note that Wichtel-Myles was the research assistant for Manente's work, and was able to observe the instruction to ensure consistency when teaching her section of the Educational Psychology course. Also, Wichtel-Myles assisted with the grading of Manente's findings, which helped to ensure grading consistency across both studies, but an additional research assistant was recruited to assist with grading Wichtel's data.

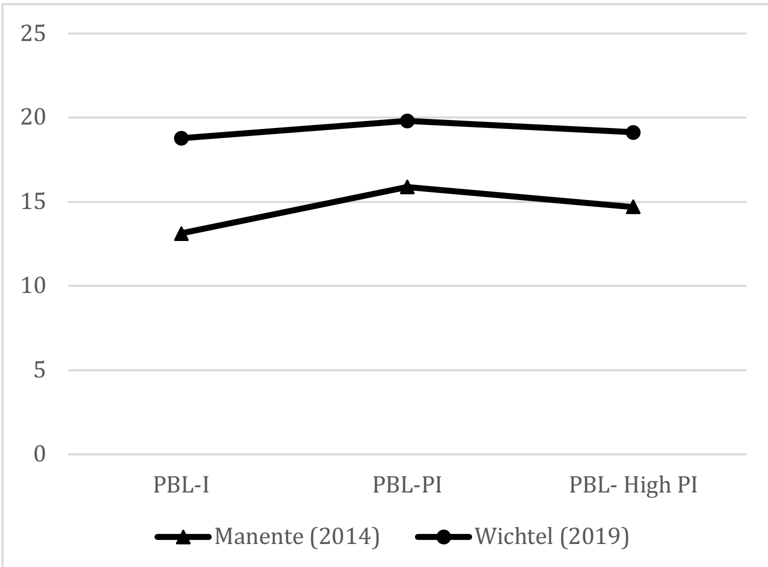

Figure 10: Mean comparison of take home finals across Manete's (2014) study and Wichtel-Myles' (2019) Mean Comparisons

In-class final scores. The in-class examination scores could not be compared because, it is unclear how the primary investigator of Manente's (2014) study calculated the mean. However, when trends for the three conditions were compared visually, similar trends are represented.

Summary. Overall, analyses support the idea that concept maps lead to improved performance during PBL. There is also evidence that when students work individually, they are not receiving the benefits that come from collaborative learning and may be less able to learn new material if cognitive demands are too great. Incorporating concept maps into collaborative learning enables students to receive support from their instructor and peers in ways that are not always possible when working alone. In particular, the instructor's ability to passively monitor group discussion or review concept maps makes it possible for the instructor to intervene when necessary in ways that are tailored to the unique needs of the students. This, combined with the demonstrated value of effective collaborative learning, ultimately provides students with more resources throughout the problem-solving process, and in turn, produces better learning outcomes.

Impact of conceptual gains on performance outcomes. A second component of the first research question explored whether students' conceptual gains when using concept maps were associated with change in performance on problem solutions, comprehension assessments, and final exams. A closer look at the pattern of conceptual gains and scores across groups may offer some insight into this question. Group 1 had the fewest conceptual gains, across all groups, during the PBL-PI/CLT (gains = 3) and the PBL-High PI/SCLT (gains = 0) conditions. In contrast, this group had the highest problem solution scores for the PBL-PI/CLT and the PBL-High PI/SCLT conditions. Additionally, they had the lowest mean score on the comprehension assessment, take home final, and in-class final for the PBL-PI/CLT condition; as well as the lowest mean score on the take-home final and in-class final for the PBL-High PI/SCLT condition. They had the second lowest mean score for the comprehension assessment for this condition as well. Lastly, they had the lowest overall take-home final score and in class final score. In sum, Group 1 had the fewest conceptual gains in both collaborative concept maps, the highest scores for both collaborative problem solutions, and some of the lowest scores for all summative assessments. Ultimately, these patterns provide an inconsistent picture of the impact of conceptual gains on performance outcomes in PBL. It does not appear that fewer conceptual gains are indicative of lower problem solution scores (e.g. Group 1); however, it does appear that fewer gains may be indicative of lower scores on overall assessments of the target concepts. Reasons for these outcomes could be that comprehension assessments test domain specific knowledge, by measuring their ability to apply the course content to open-ended questions.

Students had to communicate, define, and elaborate on as many concepts associated with the focus top. Also, when taking the comprehension assessment students did not have specific prompts like they did during the problem solutions. Students were not required to make a concept map when taking their comprehension assessment, however, they were permitted to do so if they chose to. It is important to note that no students elected to make a concept map during the assessment.

Group 3 had the highest number of conceptual gains, across all groups, for both the PBL-PI/CLT (gains = 68) and PBL-High PI/SCLT (gains = 26) conditions. This group had the second highest problem solution score for the PBL-PI/CLT condition, and the second highest problem solution score for the PBL-High PI/SCLT condition. Additionally, they had the second highest score on the comprehension assessment and take-home final, as well as the second highest score for the in-class final, related to the PBL-PI/CLT condition. They also had the second highest score for the comprehension assessment, take-home final, and in-class final related to the PBL-High PI/SCLT condition. Lastly, they had the second highest overall take-home final score, and third highest overall in-class final score. It was noted earlier that these groups used cross-links within their concept map to connect concepts from different domains. The purpose of the problem-solutions and the comprehension assessments was to assess domain-specific content on a focus topic, therefore, the pattern of the scores from Group 3 provides evidence that more conceptual gains could lead to higher performance outcomes.

One of the key factors that may explain the patterns of results seen in the relationship between conceptual gains and student performance outcomes is that the purpose of concept maps is for students to exchange conceptual knowledge. As a result, if a group focused on solving the problem and primarily discussed logistics related to that goal, or focused their discussion on only a few concepts most relevant to solving the problem, then this could have resulted in strong problem solutions but lower summative assessment scores due to a lack of deep conceptual understanding. And, this lack of deep understanding would be consistent with a lack of conceptual gains. Conversely, if a group's discussion focused on conceptual understanding as opposed to solving the problem, this could have resulted in a lower problem solution score and higher summative assessment scores, given that summative assessments placed a greater focus on the acquisition of conceptual knowledge. Another possibility is that Group 3 placed such an emphasis on including a larger quantity of concepts in their first map that they did not focus sufficiently on incorporating the concepts into their written problem solution. Ultimately, however, while some correlation may exist between conceptual gains and student outcomes, overall gains do not appear to consistently reflect student performance on problem solutions and summative assessments.

PBL instructional designs and SSR. The second research question explored which PBL instructional designs provide opportunities for students to engage in SSR. Group discussions during both PBL-PI and PBL- High PI were analyzed to determine the extent to which these designs provided opportunities to engage in SSRL. The results showed that all groups exhibited high quality SSR (i.e., task planning, plan monitoring, and progress monitoring) during the PBL-High PI condition. It is important to note that the conversations produced during the PBL-I/BLT condition were not analyzed for SSR processes, because the design did not have a collaborative element. However, while it is beyond the scope of this paper, there would be value in future research that analyzes the extent to which individual's self-regulatory strategies in the PBL-independent condition relate to their degree of participation in the co-regulation and SSRL in the collaborative conditions.

SSR processes exhibited during PBL. A second component of question 2 looked in more detail and the kinds of SSR processes exhibited by students when working on PBL activities.

Planning. As stated above, qualitative analyses revealed that while all groups exhibited processes of SSR, not all groups sustained instances of high-quality SSR. High quality task planning occurred most often when students used the information gathering sheet during the PBL- High PI condition. Instances of low-quality task planning occurred most often during the PBL-PI condition, as there were members of the groups that jumped ahead and did not ensure that all members had a thorough understanding of the case instructions. Notably, Groups 2 and 4 did not initially engage in discussion related to the plan (i.e., task planning or monitoring of the plan) during PBL-PI; however, after they accessed course material and conducted research on the topic, they were more active in group discussions related to the plan. This may point to the impact that a lack of understanding of a concept or theory may have on students' ability to engage in SSR.

Instances of high-quality content planning was demonstrated during the second session of each PBL condition across all groups. This was likely the case because many of the groups had little knowledge of the concepts associated with the theories presented in each case until after they conducted research. As a result, it is possible that after completing additional reading between class sessions, members had more knowledge, were able to engage more deeply with the content, and could compose a better group plan.

Monitoring. High-quality content monitoring occurred during the second session of PBL-High-PI, and was exhibited by Groups 1 and 4. A common characteristic of the groups that exhibited high-quality content planning and high-quality content monitoring was that they referenced their pre-and post-concept maps throughout the problem solving process. While plan monitoring did occur, it was the least exhibited process throughout all problem solutions across all groups. It occurred during the second session of each problem solution when group members from Groups 1, 3, and 4 checked to make sure they were meeting the expectations of their previously established plans. There was an instance in which the instructor had to remind students from Group 2 to ensure they were meeting their original goals, which prompted students to engage in high quality plan monitoring. However, because these instances were prompted they did not count as high-quality interactions.

Groups 1 and 4 consistently demonstrated high-quality progress monitoring; whereas, Groups 2 and 3 exhibited instances of both high- and low-quality progress monitoring. Differences in the groups' uses of monitoring could be seen in the groups that used high-quality task planning and high-quality content planning. The use of high-quality planning made it more likely for groups to engage in progress monitoring because they had the groups collective determination of how they would proceed with the problem solving process to reference when exhibiting monitoring their progress. Groups used progress monitoring by recognizing tasks they have completed and what was left to complete in order to make sure that they had completed all the tasks they had identified when discussing the instructions for the problem solution. Groups used progress monitoring when determining how much time they had left within the session in order to ensure they had enough time to review the content as a group for the comprehension assessment. In sum, high-quality progress monitoring, was not possible without high-quality task planning, and high quality content planning; without a well throughout out plan it was difficult for groups to monitor progress.

Behavioral engagement. A few of the low-quality behavior regulatory strategies groups used have already been discussed, but were not highlighted as such. Common examples were instances in which an individual did not contribute to group discussion and group members did not encourage that member to reengage and participate, or when the instructor observed instances in which a group member was disengaged she would provide the disengaged individual with thought provoking question. For example the instructor asked a member from Group 2, "what do you think the differences are between the various types of memory discussed in the chapter on cognition?" Questions such as these aimed to prompt the disengaged group member to contribute to group discussion, and prompt the other group members to listen to the group members' answer. However, questions such as these also inadvertently served as a way for the instructor to check for student understanding of the content. For example, when this question was presented to the learner, the learner could not adequately explain the various types of memory (i.e. episodic, semantic, procedural, declarative, etc.), while it did provoke group discussion, and did ensure the group members were attending to the disengaged individual, it also could have negatively contributed to the group cohesion. More specifically, if a group member thought that the individual did not complete the reading related to the material, they may have thought their contributions were not sufficient and may not have incorporated their ideas into the overall group product. High-quality behavior regulatory strategies were exhibited and sustained by Groups 1, 3, and 4, in all collaborative conditions. Group 2's lack of use of behavioral engagement could have contributed to the outcomes they produced.

Socioemotional interactions. Small socioemotional interactions can be difficult to monitor; however, the presence of positive socioemotional interactions is imperative to ensure when students provided each other with feedback throughout the PBL conditions. Examples of these types of interactions are active listening and respectful exchanges. There were instances in which a group member was not included in a group task which represented low-quality behavioral regulation; however, but, there were not instances in which a group member was disrespected or discouraged from participating which would have been negative socioemotional interactions. Additionally, groups exhibited instances of high-quality vocal socioemotional interactions (e.g., speaking respectfully, praising each other's' contributions etc.); however the quality of these interactions was not a primary focus of this study because a thorough analyses of the degree to which these interactions took place would have required the review of video recordings to determine any situations in which students exhibited gestural or body cues that represented either positive or negative socioemotional interactions. Nevertheless, it appears positive vocal socioemotional strategies were prevalent across all groups in which group members encouraged one another and commended one another's contributions which contributed to the group products produced by the groups.

Impact of concept maps on SSR quality. The third research question explored to what degree concept maps impacted the quality of SSR exhibited within small group work. However, based on the structure of this study, the impact of concept maps on the quality of SSR cannot be precisely identified. However, it is clear that group SSRL processes were exhibited when students engaged with their concept maps and referenced them when solving the problem solutions. In order to explore how the frequency of high quality SSR could be influenced by concept maps, one would need to explore the quality of the concepts placed on the map. By determining the quality of the content placed on the map one might be able to determine if those groups who exhibited more frequent instances of high quality regulation also produced a more high quality content on their map. Also, future research might aim to determine frequency counts of how often groups referred to their map in order to determine if a correlation exists between frequent referencing of concept map and high quality socially shared regulation. Frequency counts could be identified via the recorded conversations and the video tapes.

Use of High-quality SSR during concept mapping. A secondary question explored whether students engaged in high-quality SSR when using concept maps as a tool to solve problems. Results demonstrated that learners did exhibit high-quality SSR when using concept maps during the interdependent PBL environments, which supports the use of concept mapping as an effective tool to support learners in collaborative contexts. It was also notable that concept maps appeared to promote increased high-quality content planning and monitoring. As students accessed additional resources, they would revisit their maps, elaborate on the previously discussed concepts, and discuss rationales for why these concepts should be incorporated into their content plans. The use of concept maps was also linked to instances of high-quality content monitoring during the PBL-High PI/SCLT condition. These findings are consistent with Rogat and Linnenbrink-Garcia (2011) who notes "a key element of high level content monitoring was the focus on ensuring group member's understanding of the content" (2011; p.390) It could be that the PBL-High PI condition emphasized the focus of content monitoring since it was imperative that each group member understood the content for comprehension assessment which would be evaluated through Team Assessment. For example, though Group 1 exhibited fewer conceptual gains on their concept map, but engaged in a higher degree of enriched discussion regarding what should be on the map and chose to prioritize including the prominent concepts on the map rather than getting as many concepts on their map as possible. One of the main purposes of concept maps is that they are a useful learning strategy for learners to determine what they know, and what they need to find out.

Student centered instructional design and High-quality SSR. An additional follow-up question sought to identify what student centered PBL instructional designs provide opportunities for students to engage in high quality SSR when using concept maps as a tool. Results demonstrated that the PBL-High PI design produced the best student outcomes when also using concept maps as an instructional support. As noted earlier, this design combination led to the highest scores on both collaborative comprehension assessments and problem solutions because students were dependent on one another to develop a viable solution to the problem and have full understanding of the concepts since their grade would impact the scores of their peers.

The concept maps were useful in supporting content-monitoring, especially when groups constructed their revised maps as they discussed which concepts they should place on the map and how they should be connected. While some groups' members initially place concepts on the map without consulting with their group, eventually all groups, except Group 2, collaboratively discussed all concepts that were placed on their revised maps to ensure that everyone understood the concept and its relation to other concepts and the theory. This degree of collaboration was likely seen in the High PI condition because students recognized that their grades were heavily dependent on each other and they could easily visualize their group's conceptual understanding by referencing their concept map.

High quality progress monitoring was also more apparent during the PBL-High PI condition. This may have been due to the fact that all groups had to ensure that everyone knew the material for the comprehension assessment, as several groups made comments related to how much they had to accomplish, and how much time they had to review as a group, before sitting down for the comprehension assessment.

The use of concept maps in the High PI condition may also have led to more instances of high quality instances of behavioral engagement, as group members provided each other with reminders that were to work on the problem solution collaboratively. For example, many group members would remind other group members that they all needed to be involved in the work product. There were a few instances in which a group member would look at the concept map and notice another group member did not contribute to the physical development of the concept map, and suggest they add a concept. Lastly, all groups chose to review the concepts associated with SCLT after the completion of their map to ensure everyone understood the concepts.

Positive Interdependence and high-quality SSR. Lastly, this study sought to explore how “team evaluation” (PBL High-PI) fosters a higher level of interdependence and sustained collaboration, and, in turn, supports high quality socially shared regulation. As discussed previously, results from this study showed that students performed best and engaged in more consistent high-quality SSR in the PBL-High PI condition. Thus, it is important to consider how the High-PI condition contributed to such strong student scores on problem solutions and concept maps, as well as and the ways in which groups exhibited high-quality SSR during this condition as well. The High-PI condition was designed to promote the development of mastery goals by fostering cooperation rather than competition between peers within the work groups. The promotion of mastery goals is a key component of Belland et al.’s (2013) framework, and has been supported by research on social interdependence theory (Johnson & Johnson, 2005; Johnson, Maruyama, Johnson, et al., 1981). As noted earlier, research on social interdependence theory focuses on positive goal interdependence which emphasizes that positive goals and reward interdependence are needed to maximize student achievement (Johnson, Maruyama, Johnson, et al., 1981). Positive reward independence occurs when all group members receive the same reward, such as the group grade that was earned during the High-PI condition. Positive goal interdependence occurs when students perceive that they can achieve their learning goals if all members of the group also attain their goals, which was also ensured during the High-PI condition by averaging individual group member's grades together. The instructor ensured that the groups understood that they should have mutual goals, including ensuring that their peers were active participants in the problem solving process and that they understood the interworking of their finalized problem solutions, and associated concepts, in order to complete the task. Positive resource interdependence was also created during this study, as group members were dependent on each other to share the concept maps, information gathering sheet, and problem solution worksheet in order to accomplish their shared goals. According to Johnson and Johnson (2002), combining goal and reward interdependence increases achievement to a greater degree than goal interdependence alone. As such, the presence of both factors in the PBL-High PI condition may have contributed to the positive outcomes seen.

It is evident that positive interdependence occurred across groups during the High-PI condition, as engaging in positive interdependence was essential for a group to be able to exhibit high quality collaborative interactions. Collaborative interactions during the High-PI condition resulted in higher quality SSR because groups focused on improving conceptual understanding by engaging in planning and monitoring. While all groups did not consistently use high-quality strategies, they did practice them during portions of the session. And, ultimately, it was only during the PBL-High PI condition that all groups exhibited high-quality content planning and high-quality content monitoring. Overall, the success of students in the PBL-High PI condition appears linked to the fact that this condition, more so than the other two study conditions, had the greatest number of evidence-based characteristics for increasing effective group shared regulation and collaboration.

Contributions to Existing Literature

Problem-based Learning (PBL) has been heavily practiced and researched among educators and across academic contexts, perhaps more than many other instructional designs. However, despite this, there are still many unknowns in terms of factors that can help improve students' ability to make effective use of collaborative skills in the classroom setting, The findings of the current investigation contribute to this literature by presenting collaborative concept mapping as a tool that can increase student learning outcomes in PBL. This study also addressed the use of motivational scaffolding, questions related to concept mapping and cognitive load, the debate regarding whether collaboration is essential to PBL, as well as ways it concept mapping can support processes of socially shared regulation using PBL.

While some researchers have found concept maps to be beneficial for student learning outcomes, others have asserted that the use of concept maps in PBL warrants further investigation before drawing conclusions as to their effectiveness (Zwall & Ottings, 2012). The current study contributes to this literature on concept maps and performance outcomes, by offering an opportunity to directly compare the outcomes of students who used concept maps with those students in Manente (2014) who did not use them, while holding other design features constant. (Manente, 2014). As a result, it was possible to show that students scored higher on comprehension assessments and take-home finals and to link that positive difference to the use of concept maps in a way that has not been possible in previous literature.

A great deal of research dedicated to understanding how concept maps contribute to the effectiveness of PBL has been deeply rooted in medical and nursing education (Hsu, 2004).

These studies have offered significant support for the use of concept maps, and this investigation extended that support by looking at the benefits within more general educational contexts. Additionally, the current study is unique in that explores the student learning outcomes even more deeply by working to understand how the motivational scaffolds incorporated into the research design led to the effectiveness.

The findings of this study contribute to literature on motivational scaffolds to support students in PBL, especially undergraduate students, by providing additional support for the value of information gathering sheets and problem solution worksheets as scaffolds that effectively require students to consider their peers when making decisions and formulating solutions to the questions on the shared worksheets (Belland, Kim, & Hannafin, 2013). Ways to scaffold student learning during PBL, has been a challenge, as there is typically one instructor present with multiple groups. This investigation also demonstrated that group concept maps can serve as a tool to address challenges identified in previous research related to the ability of individual instructors to effectively identify unique student needs and scaffold multiple students across multiple groups. This also builds on literature associated with the pivotal role teachers play during PBL in supporting the use of motivational scaffolds (Belland, 2012; Hmelo-Silver & Barrows, 2006). Although a simple learning strategy, the use of a concept maps in higher education is often overlooked as a resource. However, the current investigation provides ample support for the idea that they are a suitable strategy for enabling instructors to monitor multiple groups efficiently, and to more effectively scaffold student learning.

Researchers have also tried to understand how the inclusion of concept maps could lead to the reduction of cognitive load in multiple domains (Basque & Lavoie, 2006; Hu & Wu, 2012). These studies have generally supported the idea that the use of concept maps does reduce cognitive load, particularly when gradually integrated over time (Basque & Lavoie, 2006; Hu & Wu, 2012). This study offered similar support for the positive impact of concept maps on cognitive load when used in collaborative learning settings, but highlighted the possibility that concept maps may actually increase cognitive load when used for individual learning.

Lastly, findings from this investigation add to the literature on collaboration and socially shared regulatory processes. There has been debate as to whether or not collaboration is important in order for PBL to provide the most beneficial outcomes, with some researchers arguing that collaboration is not necessary (Wirkala & Kuhn, 2011). However, the results of the current study build on Manente's (2014) findings which supported collaboration as a necessary component for successful PBL outcomes. The current study also extended these findings to explore the interrelationship between evidence-based practices to increase collaboration and group regulatory processes. Researchers have worked to identify ways in which educators can promote socially shared regulation, but identified the need to further explore ways to increase positive interdependence in order to foster higher quality SSR (Rogat & Linnenbrink-Garcia, 2011; 2013). The current study offered insight into this by presenting embedded team evaluation and collaborative concept mapping as two PBL strategies that would enable an instructor to foster such higher quality SSR.

Limitations

While this study offers significant findings and numerous contributions to existing literature, there are also several limitations worth noting. One of the most valuable aspects of any research study is the ability to generalize the findings to situations, settings, or populations outside of those involved in the study itself. However, this can also be an area that is limited by aspects of the study design. For the current study, one way of generalizing the findings would be an ability to understand how individuals learn in collaborative groups when engaging in PBL experiences across different types of settings. One way of testing this would be to explore whether the effectiveness of the design principles used in this study, particularly Belland et al.'s (2013) scaffolding design framework, were equally effective for collaborative learning in other settings. The current study employed the framework in a higher education, general psychology forum. Additionally, the study only used one type of collaborative learning task (PBL), in one domain (Educational Psychology), with most of the enrolled students sharing the same educational level and major (undergraduate, education). Thus, the ability to apply current findings to other settings (e.g., secondary schools), fields/domains (e.g., mathematics, economics), populations (e.g., graduate students, professionals), or other forms of collaborative learning (e.g., teacher preparation programs) may be limited; and any assumptions must be made carefully.

Participants. Another limitation relates to the selection of study participants. Randomized selection of participants with a control group is generally considered the study design most likely to generate results that can be extended to other groups. Given the design of this study, a control group was not possible and, while the instructor had no control or direct influence on the students who enrolled in the course, there are ways in which the randomization of participants may have been limited by study design. First, as mentioned above, all students were education majors as the course was a course that was unlikely to be taken by students from other majors; thus, the potential participant pool was immediately limited to a smaller subset of all students at the university.

As part of informed consent, the fact that the course would be taught differently than other sections of the same course was noted in the course description provided to the students at the time of registration. Thus students had the option of enrolling in the mixed-method course for this study or taking an alternative section of the course that used a more traditional lecture/discussion format. This is notable because this may have had an impact on course make-up, as there may be something about the students who self-selected to enroll in a unique section of the course that differentiates them from students who opted to enroll in the traditional course. Additionally, there were also a number of students who attended the first class meeting but did not attend the second course meeting and opted to be removed from the course. These students may also have decided that they were not interested in participating in the course design used in the study, further differentiating the final 20 students from the larger pool of possible participants.

It is also noteworthy that of the 20 students who were enrolled in the course, 4 students opted to remain in the course but not participate in the study. These students were grouped together to limit their possible impact on the overall data; however, their choice further limited the randomization of the 16 students whose data was ultimately analyzed for the study. There is no way to know in this context how this subset of participants differs from the students who did not participate; and thus it is possible that the outcomes are in some way unique to these students and might not be replicable in other populations.

Data. The data collected, and upon which this study was based, also serves as a limitation. This study relied on observable instances of interaction for the SSR analyses; however, possible analyses were limited by low frequencies of behavioral engagement episodes and socioemotional episodes. In other words, because students did not frequently engage in these specific subcategories of SSR, it was not possible for the researcher to assess differences between the conditions that might generate specific types of interactions or episodes. As a result, findings from the study are extremely limited in scope, and only provide a small degree of evidence for the interpersonal trends that may occur when using differing forms of scaffolds.

Previous research. While this study aimed to extend research conducted by Manente (2014) by replicating his study design and incorporating concept maps as a unique component, there were some limitations to the degree to which the researcher was able to accurately compare data. Because the exact scores of Manente's (2014) participants were not available, it was not possible to sufficiently compare mean scores on the problem solutions across the two studies. The distinction of how grades were allocated based on the two tier system used in Manente's study was not distinguishable. This information is important to ensure consistent evaluation of the student's work products across the various methods of assessment (i.e. problem solutions, comprehension assessment scores, and take-home finals) in order to determine how the conditions impacted student and group performance outcomes.

Timing. Student ability to become familiar with the materials, and learn the concepts, used in the study may have been impacted by the time limits imposed on each section. Instructional time was necessarily limited in order to ensure that the PBL practice and the sessions all conditions could be completed within the weeks and class sessions of the course. Given the novel idea of using a concept map and the potential performance deficits stemming from high cognitive load, is it possible that extra instructional time to allow students to become better acquainted with how to construct a concept map may have been beneficial. Additionally, if more time was allotted for training students, they may have had greater comfort with including more elements into their map. Specifically, students did not use propositional statements, or short phrases that can be used to further describe a relationship between two concepts, when incorporating links into their map. More time for training may have also provided students with the opportunity to recognize that they could use cross-links to make visual connections between concepts within different domains. Overall, limiting the time students had to acquire and develop knowledge of how to construct a map could have weakened the impact of the maps had on student outcomes and the quality of their SSR

Assessment. The ways in which overall student learning were assessed may have also impacted the outcomes of the study, as the degree of support students received shifted significantly from the comprehension assessments and problem solutions (i.e., high volume and frequency of support from peers and instructor) to the in-class and take-home finals (i.e., no support). Students had the greatest amount of support when they engaged in the PBL-High PI condition, but performed the best on both the in-class final and take-home final during the PBL-PI condition. Though the differences in summative assessment scores were not great, the change it is still an area that should be addressed. It is possible that, in removing the support prior to the exams, scaffolds were taken away too quickly which was reflected in lower scores after students had become accustomed to higher degrees of support. Thus, outcomes may have been different had the study design allowed for a more gradual shift in the addition or subtraction of scaffolding and assessment.

Research exploring PBL has also identified challenges for learners related to open-ended response assessment, because they do not give a definitive answer, making it sometimes difficult to determine if students have met learning goals (Boud & Feletti, 1998). Given that the comprehension assessment taken by students used an open-ended question structure, it may be the case that performance suffered and impacted results. In addressing this, Boud and Feletti, (1998) found that PBL is better assessed with a higher number of questions requiring shorter responses instead of one question with a long response. Thus, future instructional designs could aim to break down the comprehension assessment, from the take-home exam, into smaller more manageable parts. Utilizing these shorter questions may provide just enough scaffolding support for students such that their final scores are more reflective of the conceptual gains seen in the study.

Suggestions for Further Research

There are several additional questions that could be explored to improve upon the current study design, and to further investigate ways of supporting learners during PBL, fostering SSRL during collaborative learning, and incorporating the use of concept maps within this learning environment.

Cognitive load. The impact of concept maps as a source of cognitive load was a factor that potentially influenced student performance in the current study. The construction of a concept map requires many skills that can be challenging for students to acquire at times. Cañas and Novak (2006) found several difficulties that seem pervasive across students who are new to concept mapping, including difficulty with the construction and structure of propositions, and a tendency to create maps that are descriptive (i.e., describing characteristics) or classificatory (i.e., depicting process and outcomes) rather than explanatory (i.e., to connect ideas). As such, there are numerous considerations that must be taken into account when teaching students to create concept maps.

While students in this study were educated on the use of concept maps and had an opportunity to create one during the practice problem, the time allotted was limited. Students did not perform as well during the PBL-I condition, and resulted in lower scores on problem solution in comparison with the other two conditions. It is possible that requiring students to learn and execute all the necessary prerequisite skills to create a map independently while also introducing them to PBL was too much at once, especially when asking them to perform all of the PBL skills independently as well (i.e. PBL-I). However, as discussed earlier, concept maps did seem to be an effective learning strategy when students were working in their group, perhaps pointing to peer support as a factor that reduces cognitive load and creates an appropriate balance of support for students.

Given this, future research could explore the following research questions: 1) Does constructing a concept map, while engaging in PBL independently, result in cognitive load? and 2) Does constructing a map during PBL in collaboration with others create a balance that reduces, or eliminates, cognitive load?

Instructor role. Instructors play a large role in PBL, as their primary roles are to help facilitate groups' working processes. Instructors also need to identify an appropriate degree of support, and need to fade their support based on the learners' performance. Too much instructional support could result in the individual, or group, being dependent on the instructor; while too little support could result in off-task behavior. For example, instructors are providing too much support, they could be suggesting that students use specific resources to find information, in which case students may not learn how to correctly identify viable resources that could aid in solving the problem. Additionally, if an instructor offers too many reminders to reference the concept map, students may not learn to recognize when to reference their concept map on their own. Or, if a teacher provides vocal prompts to students about using the map during group discussion, it may make it difficult to then fade out the teachers presence. This future research could explore: 1) To what extent does the instructor's scaffolding support impact small group social interaction when using a concept map during PBL?; 2) What are the best practices for teaching students to independently recognize their need for support during collaborative learning (Belland et al., 2013)?; and 3) How can instructors determine the appropriate degree of guidance for their learners (Hmelo-Silver, Duncan, & Chinn, 2007)?

The current study also did not specifically explore the nature of the communication strategies used by the instructor when facilitating the students, nor did it explore the impact of the instructor's direction on students' use of SSR. Thus, future research might also explore what social regulatory processes do instructors use, or are most effective, in fostering SSRL during PBL.

Instructor training. In order for instructors to provide sufficient scaffolding support, instructor training may be necessary. Previous research has found that during transition from traditional lecture-based formats to PBL, there needs to be trained staff to implement this approach (Saye & Brush, 2002). A number of faculty training programs do exist for PBL tutors, and have been found to be well-received and useful to those teachers who have participated in them (Saye & Brush, 2002; Hitchcock, Mylona, 2009; Hogan & Pressley, 1997). Outcomes of such programs have resulted in increased knowledge of teaching styles, as well as awareness of the positive teaching on participants' behaviors. Given the important of appropriate training, it may be valuable for future research to explore the value of a training program for educators to learn how to incorporate appropriate scaffolds and use concept maps paired with PBL.

Group design. Another factor that may have had an impact on study outcomes is the way in which group composition was determined. For this study, students completed a pre-test and were grouped based on scores with the goal of ensuring that there was a somewhat equivalent degree of prior knowledge of concepts across the four groups. For example, members from Group 3 and Group 4 did not have prior knowledge of concepts associated with CLT; while one member in Groups 1 and one in Group 2 had prior experience with the concepts. These results did not seem to impact the outcomes or the discussion that took place throughout the problem solving process. In other words, though the experienced members did bring their prior knowledge to their group discussions, their contributions did not override or demean others' input. Nevertheless, it is important for future research to explore whether there should be guidelines or best practices for the creation of groups within PBL environments. As mentioned above, one such way could be based on a consideration of individual self-regulatory processes exhibited by students in the PBL-I condition. Previous research has noted that process of self-regulated learning for individual group members could impact the extent to which groups exhibit SSR processes (Panadero, Kirschner, & Jarvela, 2015). Thus, future research should consider exploring: 1) Would focusing on the self-regulatory behaviors of the individual help understand how to better separate groups? and 2) What characteristics of self-regulation should be considered when creating PBL groups.

Fading scaffolds. One of the many goals of PBL is to teach learners how to solve problems independently, engage in higher-order thinking, and exhibit self-regulatory behaviors. Instructors often create materials to help support these goals, and the question prompts that were embedded in the information gathering worksheet in this study were one such support that appeared were beneficial in helping participants develop their problem solutions. However, efforts to fully support these goals often require fading out prompts to allow learners to attempt to solve problems with less assistance and, ultimately, enhance their metacognitive planning and reflection (Davis, 2006; Quintana et al., 2004). In this study, prompts were not faded, but, as an example, it would have been possible to initially provide the students with the information gathering sheet containing 6 questions and to then provide them with a new sheet with only 4 questions, etc. Ideally, the structure of prompts and fading should match student performance, but it is not always simple or straightforward to predict the best pace for removing supports (Manente, 2014). The hope is that student performance will increase as they gain exposure to the PBL process and become more competent and confident in thinking critically; however, as discussed above, students may have poorer outcomes if supports are removed too quickly or not quickly enough (Savery, 2006). Thus, it would be important for future research to explore: 1) What are the most effective ways of gradually fading out hard scaffolds in order to promote learner independence?

Concept maps. Concept maps played a significant role in this design, but the ways in which concept maps impacted student outcomes and how they can be used to enhance student learning during PBL should be further explored.

Individual contributions. The ways in which individual participants may have struggled to learn and use concept maps when working independently has been discussed, but there is also value in looking at whether or not there may have been ways to improve individual performance even within the collaborative groups. Though students in the PBL-PI and PBL-High PI conditions created their concept maps as a group, they were required to use paper and a single color marker to record their individual contributions to the concept maps throughout all problem solutions. The goal of this was for all participants to easily see their physical contributions to the maps. This component of the data was not analyzed, but may have served as a way to increase individual group members' involvement in constructing the map and engaging in group discussion. For example, this data could offer the opportunity to compare an individual's contributions to the concept map to their overall performance on the comprehension assessment to determine if great contributions led to improved scores. Additionally, if instructors were able to hone in on individual group member contributions, it might be possible to provide more support to those individuals observed to have provided few contributions to the map. Analysis of the video could also help to identify how group members responded to individuals who provided little contribution to the map; for example, identifying whether they provided support to peers or if they employed increased socioemotional and behavioral strategies to encourage these members to contribute more. As such, there might be significant value in future research exploring 1) In what ways could focusing on individual member contributions to concept maps help shed light on collaborative learning practices or help to enhance participant involvement?

Assessment Tool. The integration of instruction and assessment is a core issue and has created a lot of discussion in literature associated with PBL; however, the transition from theory to practice is difficult. As previously discussed, one reason why is because implementing PBL requires instructors to learn and take on a new role in their classrooms. The goal of PBL is to increase and then assess students' ability to think critically and apply concepts to real-world situations. As this study demonstrated, concept maps can be, and have been, used for assessment purposes; and do accurately represent declarative and procedural knowledge. However, while students do acquire declarative and procedural knowledge during PBL, these types of learning are not the overall focus. Therefore the use of concept maps as the only form of assessment may not be the most effective outcome measure. Utilizing concept maps may as a way to informally assess student learning alone, or in conjunction with an instructor assessing the overall work product, still seems like an appropriate use for this study. However, future research might want to determine more advanced ways of assessing student's concept maps that will be more representative of the skills and outcomes that have been associated with PBL. For example, looking at how students use cross-links to connect concepts might be more representative of their ability to think critically. Thus, future research could explore: 1) What are the most effective means of assessing skill acquisition and outcomes in PBL? and 2) Are there ways that concept maps could be used more effectively as an assessment tool in PBL?

Implications for Practice

The success of students in the PBL-High PI condition appears linked to the fact that this condition, had the greatest number of evidence-based characteristics for increasing effective group shared regulation and collaboration. As mentioned above, there were numerous aspects of the study design that were intentionally included to foster collaboration, socially shared regulatory process, and numerous outcomes that have been proven to be associated with PBL, while also meeting the learning goals in the educational psychology course. The success of these strategies for students in the course, speak to the value that exists if instructors can finds ways to tailor their interventions more directed with their target goals. There are often challenges to being able to do this effectively given the demands that may vary across departments and even across institutions; however, there may still be benefit to working to change even one aspect of the course or intervention design with such a goal in mind.

Conclusion

The current study demonstrates that the effectiveness of Belland et al.'s (2013) scaffolding framework can be valuable and supported in a PBL environment. The incorporation of the information gathering sheet and problem solution worksheet, in conjunction with the High-PI condition demonstrated that positive interdependence did contribute to greater learning outcomes. The use of concept maps was also demonstrated to be an effective instructional strategy during small group work, and was useful for fostering discussion, encouraging socially shared regulation (e.g., content planning and monitoring), and helping students solve problems. Concept maps were also demonstrated to be a useful reference for instructors to assist in determining when to provide the appropriate scaffolding support. Ultimately, the hope is that this study clearly communicated the importance of identifying ways of fostering SSRL in small group work, and demonstrated how instructional supports, such as concept maps, can be used to encourage these efforts particularly in PBL.

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Appendices

Appendix A: Problem I (BLT) Case

Problem I

Date:___________________

tudent Name:____

roup Number:__________

nstructions: 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).

short note of introduction to: goodpay@nblc.com

The Burrhus Frederic School (BFS) is currently seeking highly qualified classroom teachers for its elementary school program. If you are interested in working for a prestigious private academy that has a strong commitment to providing its educators with every available resource please send resume and cover letter to: bfsadmin@bfs.edu

An expanding Montessori School

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.

BFS

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 B: Problem I Information Gathering Worksheet

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.

1

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.

Appendix C: Problem I Problem Solution Worksheet

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?

1

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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?

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 D: Problem II (CLT) Case

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:

-------- 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 E: Problem II Information Gathering Worksheet

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.

1

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.

Appendix F: Problem II Problem Solution Worksheet

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?

1

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?

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 G: Problem III (SCLT) Case

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 H: Problem III Information Gathering Worksheet

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.

Appendix I: Problem III Problem Solution Worksheet

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?

1

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?

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: BLT Comprehension Assessment

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.

Appendix K: CLT Comprehension Assessment

Problem II Comprehension Assessment

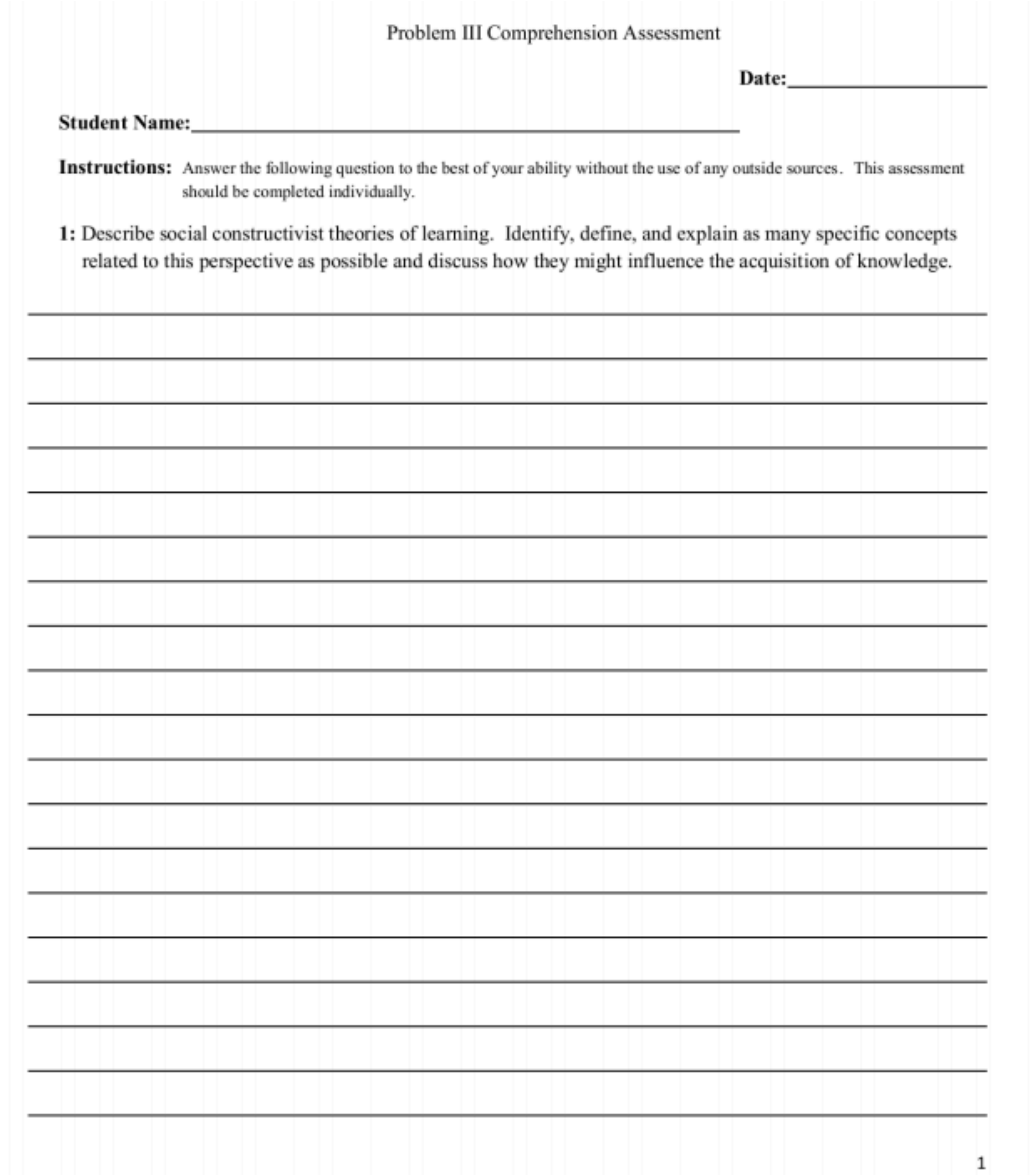
Date:____________________

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.

Appendix L: SCLT Comprehension Assessment



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.

1

Appendix M: Take-Home Final

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.

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.

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: In-Class Final

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.

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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.

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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.

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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.

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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.

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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: Research Survey

Research Survey

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

Principal Investigator: Suzanne C. Wichtel
Academic Advisor: 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 others?

4. Does your opinion of collaborative learning designs differ after taking the 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 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?

7. What method of scaffolding did you find most helpful?
   Examples of scaffolds include: information gathering, prompts presented in the problem solution worksheet, the teacher as a facilitator, or the concept maps.

8. Which method of scaffolding did you find the least helpful?

9. Rate each method of scaffolding. 1= not very helpful 5= very helpful
   a. Information gathering sheet.

      1 2 3 4 5

   b. The question prompts presented in the problem solution worksheet.

      1 2 3 4 5

   c. The concept maps.

      1 2 3 4 5

   d. The teacher as a facilitator.

      1 2 3 4 5

10. Do you think that concept maps helped you further connect ideas when developing a solution to each of the problems?

11. Do you think concept maps were helpful when working in a group? If so, why? Did your group refer to your concept map throughout the problem solutions?

12. Do you think your concept maps helped you understand the concepts related to each focus topic (i.e. BLT, CLT and SCLT)? Or, do you think you would have walked away with the same understanding without the use of a concept map?

Appendix P: Statistical Output for Comprehension Assessment

Appendix P1: *Cross Tabulation of Grader1 and Grader 2 Assessments for Comprehension Assessment Work Specimens*

		CompAssmtGrader2							Total
		0	1	2	3	4	5	6	
CompAssmtGrader1	0	3	0	0	0	0	0	0	3
	1	1	0	1	0	0	0	0	2
	2	0	2	3	1	0	0	0	6
	3	0	0	5	7	7	0	0	19
	4	0	0	0	15	28	5	0	48
	5	0	0	0	0	12	50	2	64
	6	0	0	0	0	0	1	49	50
Total		4	2	9	23	47	56	51	192

Note. Cell entries are frequency counts.

Appendix P 2: *Kappa With Linear Weighting to Measure Inter-Scorer Agreement Between Grader1 and Grader2 on Comprehension Assessment*

Kappa with Linear Weighting

Observed Kappa	Standard Error	.95 Confidence Interval Lower Limit	.95 Confidence Interval Upper Limit
0.8048	0.0242	0.7573	0.8523

0.9174	maximum possible linear-weighted kappa, given the observed marginal frequencies
0.8773	observed as proportion of maximum possible

Appendix P3: *Frequencies of Agreement (Maximum Possible, Expected by Chance, and Observed) for Inter-Scorer Agreement Between Grader1 and Grader2 on Comprehension Assessment*

Frequencies of Agreement

Category	Maximum Possible	Chance Expected	Observed
1	3	0.06	3
2	2	0.02	0
3	6	0.28	3
4	19	2.28	7
5	47	11.75	28
6	56	18.67	50
7	50	13.28	49
8			
Total	183	46.34	140

Appendix P4: *Proportions of Agreement (Maximum Possible, Expected by Chance, and Observed) for Inter-Scorer Agreement Between Grader1 and Grader2 on Comprehension Assessment*

Proportions of Agreement

				.95 CI of Observed	
Category	Maximum Possible	Chance Expected	Observed	Lower Limit	Upper Limit
1	0.75	0.009	0.75	0.2194	0.9868
2	1	0.0052	0	0	0.6042
3	0.6667	0.0191	0.25	0.0669	0.5716
4	0.8261	0.0573	0.2	0.0906	0.3746
5	0.9792	0.1411	0.4179	0.3007	0.5446
6	0.875	0.1842	0.7143	0.592	0.8128
7	0.9804	0.1514	0.9423	0.8308	0.985
8					
Composite	0.9531	0.2414	0.7292	0.6595	0.7894

Note. Confidence intervals for proportions are calculated according to the Wilson efficient-score method, corrected for continuity.

Appendix Q: Statistical Output for Problem Solutions

Appendix Q1: *Cross Tabulation of Grader1 and Grader2 Assessments for Problem Solutions Work Specimens*

	ProbSolGrader2							Total
ProbSolGrader1								
								1
								2
					8			5
					1	5		7
Total			1	5	0	7		6

Note. Cell entries are frequency counts.

Appendix Q2: *Kappa With Linear Weighting to Measure Inter-Scorer Agreement Between Grader1 and Grader2 on Problem Solutions*

Kappa with Linear Weighting

Observed Kappa	Standard Error	.95 Confidence Interval Lower Limit	.95 Confidence Interval Upper Limit
0.7999	0.0363	0.7287	0.8711

0.8592	maximum possible linear-weighted kappa, given the observed marginal frequencies
0.931	observed as proportion of maximum possible

Appendix Q3: Table 7 *Frequencies of Agreement (Maximum Possible, Expected by Chance, and Observed) for Inter-Scorer Agreement Between Grader1 and Grader2 on Problem Solutions*

Frequencies of Agreement

Category	Maximum Possible	Chance Expected	Observed
1	1	0.01	1
2	1	0.03	1
3	11	1.26	8
4	12	1.88	8
5	25	7.81	18
6	27	10.41	25
7	9	0.84	8
8			
Total	86	22.24	69

Appendix Q4: *Proportions of Agreement (Maximum Possible, Expected by Chance, and Observed) for Inter-Scorer Agreement Between Grader1 and Grader2 on Problem Solutions*

Proportions of Agreement

				.95 CI of Observed	
Category	Maximum Possible	Chance Expected	Observed	Lower Limit	Upper Limit
1	1	0.0052	1	0.0546	1
2	0.3333	0.0079	0.3333	0.0177	0.8747
3	1	0.0608	0.5714	0.2965	0.8119
4	0.8	0.0746	0.4211	0.2112	0.6603
5	0.8333	0.1656	0.4865	0.3224	0.6533
6	0.7297	0.1942	0.641	0.4715	0.7832
7	1	0.0492	0.8	0.4422	0.9646
8					
Composite	0.8958	0.2317	0.7188	0.6163	0.8035

Note. Confidence intervals for proportions are calculated according to the Wilson efficient-score method, corrected for continuity.

Appendix R: Cross Tabulations for Finals

Cross Tabulation of Grader1 and Grader2 Assessments for Finals Assessment Work Specimens

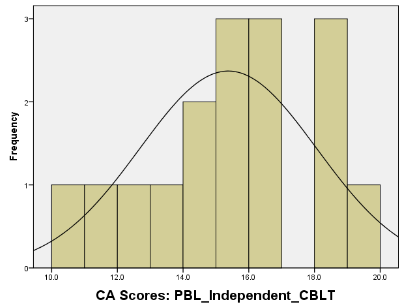
	FinalsGrader2										
		2	4	6	8	0	1	2	3	4	Total
Finals Grader1											
0											
2											
4											
5											
6											
8											
0											0
2											
4											2
Total						1					8

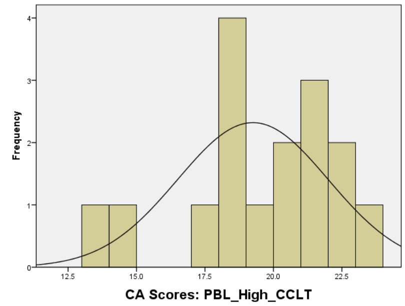
Appendix S: Descriptive Statistics for Comprehension Assessments

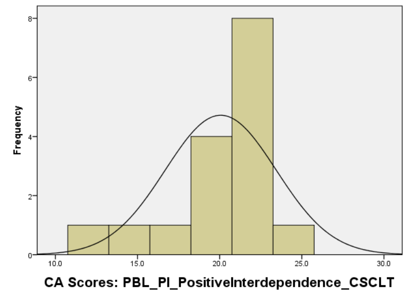
Appendix S1: *Descriptive Statistics and 95% Confidence Intervals for Comprehension Assessment Scores CBLT, CCLT, and CSCLT*

			Statistic	Std. Error
PBL_Independent_CBLT	Mean		15.375	.6731
	95% Confidence Interval for Mean	Lower Bound	13.940	
		Upper Bound	16.810	
	Variance		7.250	
	Std. Deviation		2.6926	
	Minimum		10.5	
	Maximum		19.5	
	Skewness		-.293	.564
	Kurtosis		-.649	1.091
PBL_**PI**_CCLT	Mean		19.250	.6877
	95% Confidence Interval for Mean	Lower Bound	17.784	
		Upper Bound	20.716	
	Variance		7.567	
	Std. Deviation		2.7508	
	Minimum		13.5	
	Maximum		23.5	
	Skewness		-.745	.564
	Kurtosis		.387	1.091
PBL_**High**_PositiveInterdependence_CSCLT	Mean		20.063	.8452
	95% Confidence Interval for Mean	Lower Bound	18.261	
		Upper Bound	21.864	
	Variance		11.429	
	Std. Deviation		3.3807	
	Minimum		12.0	
	Maximum		24.0	
	Skewness		-1.335	.564
	Kurtosis		1.087	1.091

Appendix S2: Frequency histograms for variables in the analysis of comprehension assessment analysis.







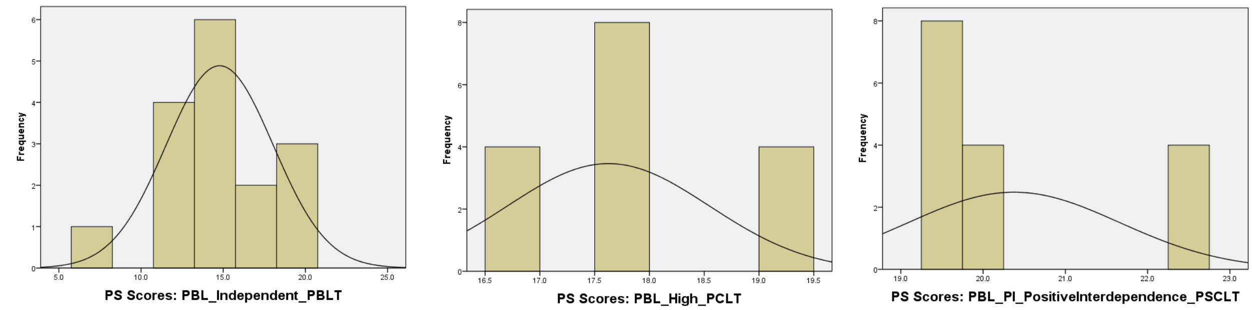
Appendix S3: *Results of Bonferroni-Adjusted Post-Hoc Comparisons for Comprehension Assessment Scores, CBLT, CCLT, and CSCLT*

1st Level of the IV in the Comparison	2nd Level of the IV in the Comparison	Mean Difference	Std. Error	Sig.	95% Confidence Interval for Difference	
					Lower Bound	Upper Bound
CBLT	CCLT	-3.875	.690	.000	-5.734	-2.016
	CSCLT	-4.688	.971	.001	-7.304	-2.071
CCLT	CBLT	3.875	.690	.000	2.016	5.734
	CSCLT	-.813	.973	1.000	-3.435	1.810
CSCLT	CBLT	4.688	.971	.001	2.071	7.304
	CCLT	.813	.973	1.000	-1.810	3.435

Appendix T: Descriptive Statistics for Problem Solutions

Appendix T1: *Descriptive Statistics and 95% Confidence Intervals for Problem Solution Scores PBLT, PCLT,and PSCLT*

			Statistic	Std. Error
PBL_Independent_PBLT	Mean		14.781	.8165
	95% Confidence Interval for Mean	Lower Bound	13.041	
		Upper Bound	16.521	
	Variance		10.666	
	Std. Deviation		3.2658	
	Minimum		7.0	
	Maximum		19.5	
	Skewness		-.733	.564
	Kurtosis		.621	1.091
PBL_**PI**_PCLT	Mean		17.625	.2305
	95% Confidence Interval for Mean	Lower Bound	17.134	
		Upper Bound	18.116	
	Variance		.850	
	Std. Deviation		.9220	
	Minimum		16.5	
	Maximum		19.0	
	Skewness		.456	.564
	Kurtosis		-.853	1.091
PBL_**High**_Positive Interdependence_PSCLT	Mean		20.375	.3211
	95% Confidence Interval for Mean	Lower Bound	19.691	
		Upper Bound	21.059	
	Variance		1.650	
	Std. Deviation		1.2845	
	Minimum		19.5	
	Maximum		22.5	
	Skewness		1.180	.564
	Kurtosis		-.549	1.091



Appendix T2: Frequency histograms for variables in the analysis of problem solution analysis.

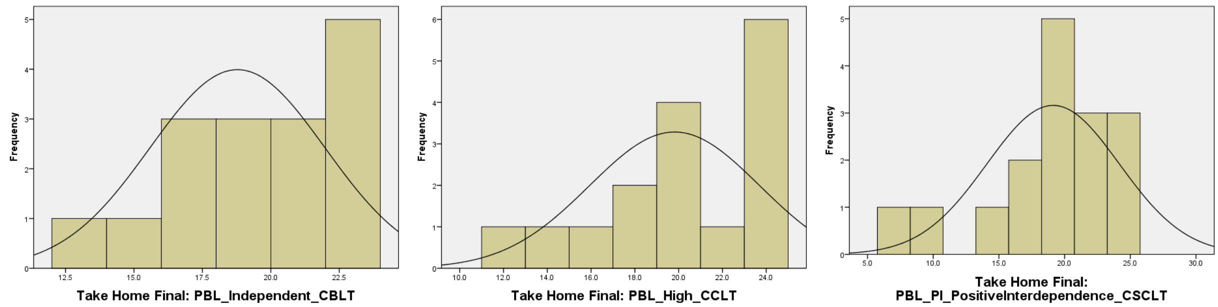
Appendix T3 *Results of Bonferroni-Adjusted Post-Hoc Comparisons for Problem Solution Scores, PBLT, PCLT, and PSCLT*

					95% Confidence Interval for Difference	
1st Level of the IV in the Comparison	2nd Level of the IV in the Comparison	Mean Difference	Std. Error	Sig.	Lower Bound	Upper Bound
PBLT	PCLT	-2.844	.846	.013	-5.123	.564
	PSCLT	-5.594	.915	.000	-8.060	3.128
PCLT	PBLT	2.844	.846	.013	.564	.123
	PSCLT	-2.750	.194	.000	-3.272	2.228
PSCLT	PBLT	5.594	.915	.000	3.128	.060
	PCLT	2.750	.194	.000	2.228	.272

Appendix U: Descriptive Statistics for Take-Home Final

Appendix U1: *Descriptive Statistics and 95% Confidence Intervals for Take Home Final Scores CBLT, CCLT, and CSCLT*

			Statistic	Std. Error
PBL_Independent_CBLT	Mean		18.781	.7997
	95% Confidence Interval for Mean	Lower Bound	17.077	
		Upper Bound	20.486	
	Variance		10.232	
	Std. Deviation		3.1988	
	Minimum		12.0	
	Maximum		23.5	
	Skewness		-.438	.564
	Kurtosis		-.443	1.091
PBL_**PI**_CCLT	Mean		19.813	.9713
	95% Confidence Interval for Mean	Lower Bound	17.742	
		Upper Bound	21.883	
	Variance		15.096	
	Std. Deviation		3.8853	
	Minimum		12.0	
	Maximum		24.0	
	Skewness		-.672	.564
	Kurtosis		-.385	1.091
PBL_**High**_Positive Interdependence_CSCL T	Mean		19.125	1.2620
	95% Confidence Interval for Mean	Lower Bound	16.435	
		Upper Bound	21.815	
	Variance		25.483	
	Std. Deviation		5.0481	
	Minimum		7.0	
	Maximum		24.0	
	Skewness		-1.414	.564
	Kurtosis		1.590	1.091

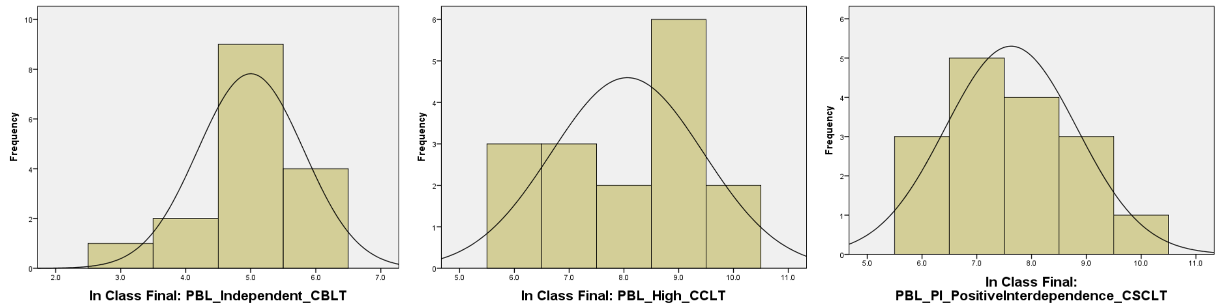


Appendix U2: Frequency histograms for variables in the analysis of take home final scores.

Appendix V: Descriptive Statistics for In-Class Final

Appendix V1: *Descriptive Statistics and 95% Confidence Intervals for In-Class Final Exam Scores CBLT, CCLT, CSCLT, and Total Scores*

			Statistic	Std. Error
PBL_Independent_CBLT	Mean		5.000	.2041
	95% Confidence Interval for Mean	Lower Bound	4.565	
		Upper Bound	5.435	
	Variance		.667	
	Std. Deviation		.8165	
	Minimum		3.0	
	Maximum		6.0	
	Skewness		-.840	.564
	Kurtosis		1.223	1.091
PBL_**PI**_CCLT	Mean		8.063	.3472
	95% Confidence Interval for Mean	Lower Bound	7.322	
		Upper Bound	8.803	
	Variance		1.929	
	Std. Deviation		1.3889	
	Minimum		6.0	
	Maximum		10.0	
	Skewness		-.297	.564
	Kurtosis		-1.275	1.091
PBL_**High**_Positive Interdependence_CSCLT	Mean		7.625	.3010
	95% Confidence Interval for Mean	Lower Bound	6.983	
		Upper Bound	8.267	
	Variance		1.450	
	Std. Deviation		1.2042	
	Minimum		6.0	
	Maximum		10.0	
	Skewness		.319	.564
	Kurtosis		-.662	1.091
Total	Mean		20.688	.3619
	95% Confidence Interval for Mean	Lower Bound	19.916	
		Upper Bound	21.459	
	Variance		2.096	
	Std. Deviation		1.4477	
	Minimum		17.0	
	Maximum		23.0	
	Skewness		-.880	.564
	Kurtosis		1.613	1.091



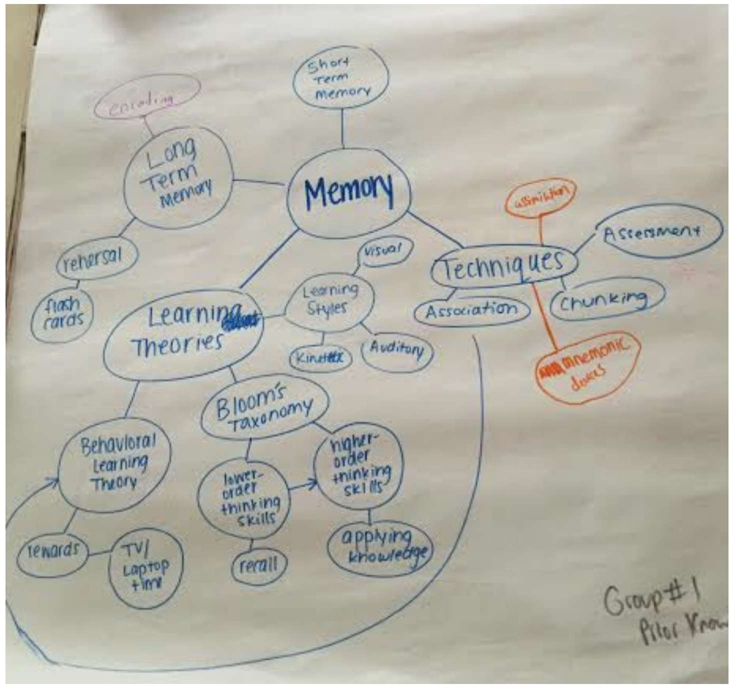
Appendix V2. Frequency histograms for variables in the analysis of problem solution analysis.

Appendix V3: *Results of Bonferroni-Adjusted Post-Hoc Comparisons for In Class Final Scores, CBLT, CCLT, and CSCLT*

					95% Confidence Interval for Difference	
1st Level of the IV in the Comparison	2nd Level of the IV in the Comparison	Mean Difference	Std. Error	Sig.	Lower Bound	Upper Bound
CBLT	CCLT	-3.063	.413	.000	-4.175	1.950
	CSCLT	-2.625	.417	.000	-3.749	1.501
CCLT	CBLT	3.063	.413	.000	1.950	.175
	CSCLT	.438	.532	1.000	-.996	.871
CSCLT	CBLT	2.625	.417	.000	1.501	.749
	CCLT	-.438	.532	1.000	-1.871	.996

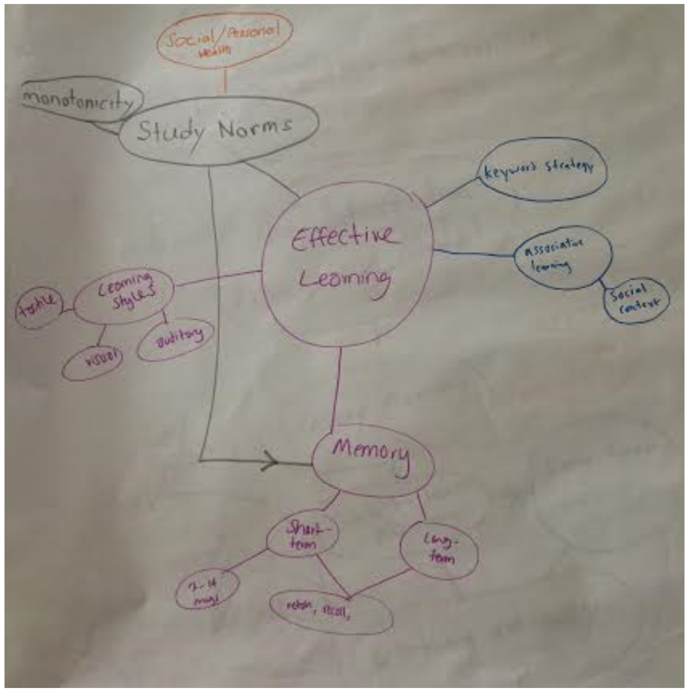
Appendix W: CLT Pre- and Post-Concept map Group 1

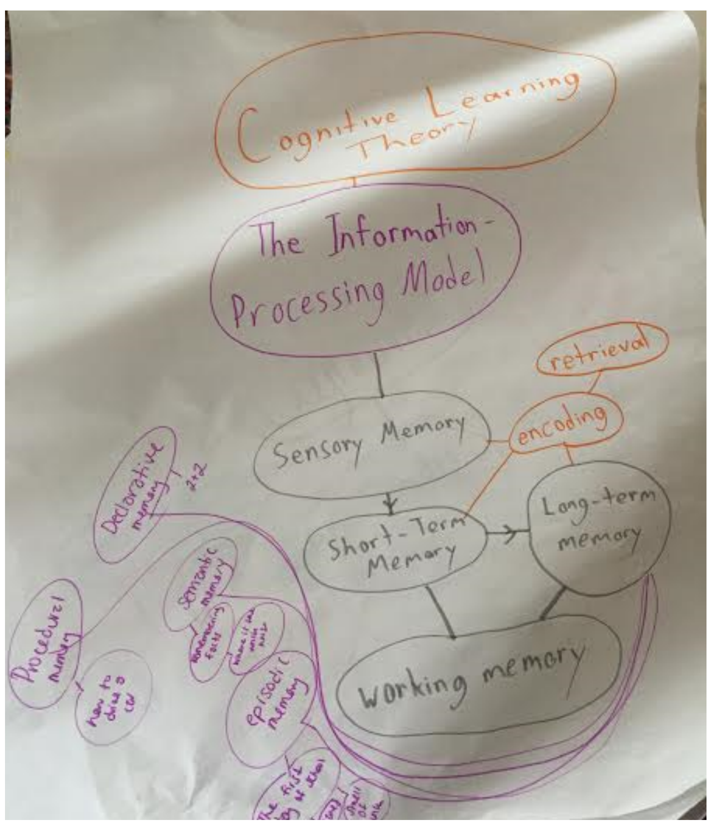
CLT: Group 1



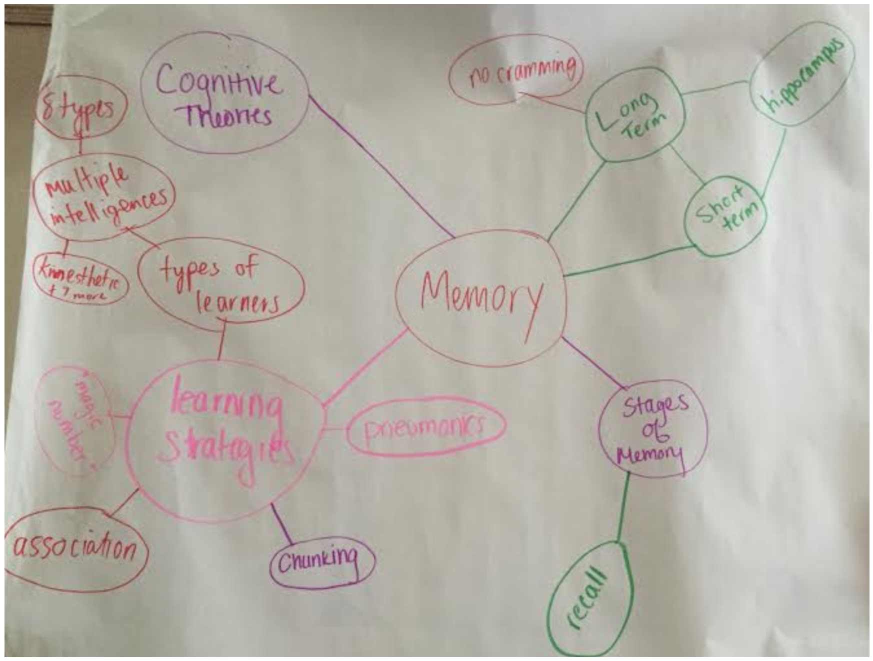
Appendix X: CLT Pre- and Post- Concept Map Group 2

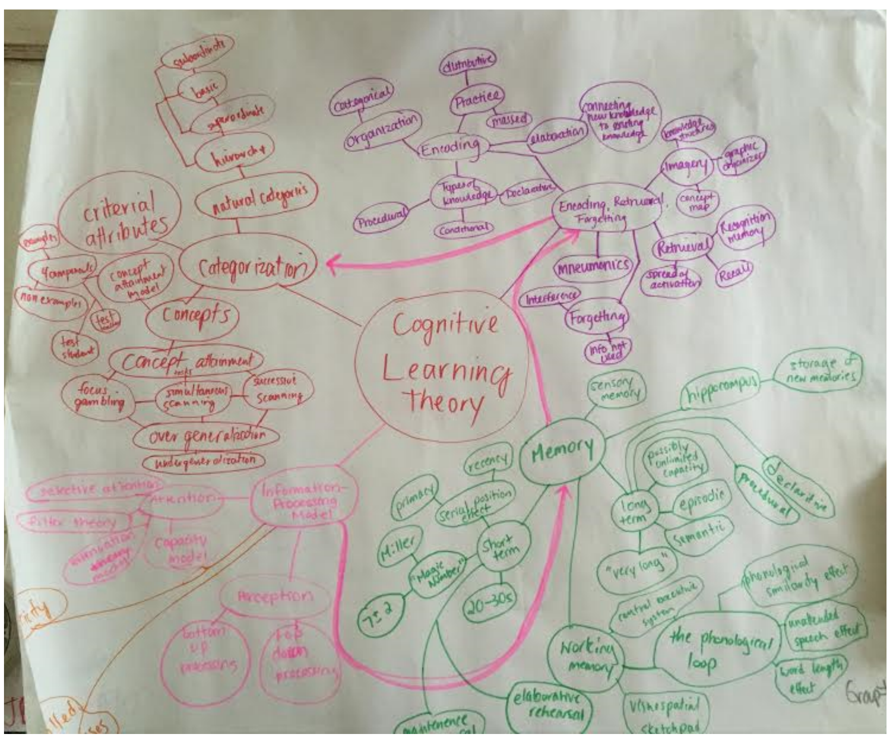
CLT: Group 2, Pre- (above) and Post- (below) Concept Maps





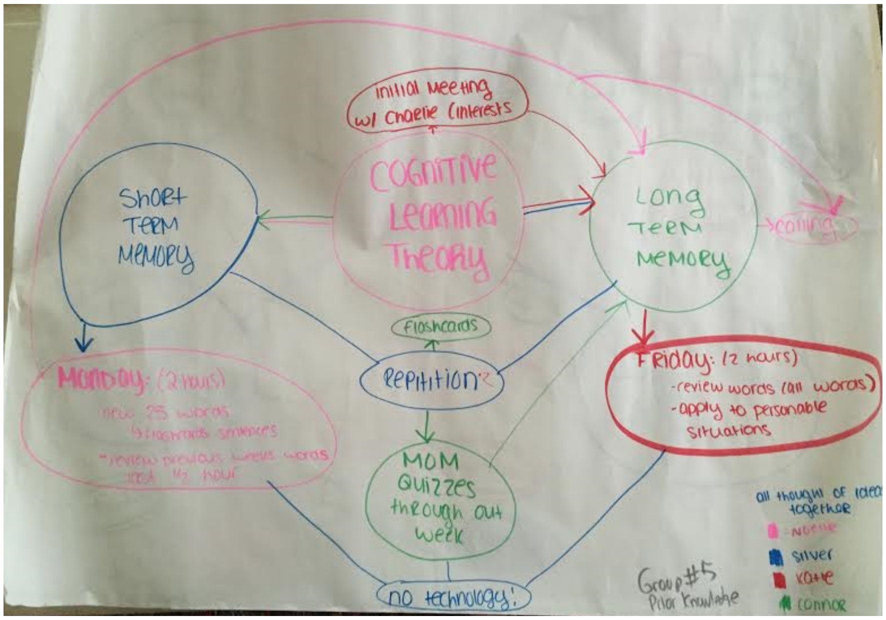
Appendix Y: CLT Pre- and Post- concept maps Group 3CLT: Group 3 Pre- (above) and Post- (below) Concept Maps

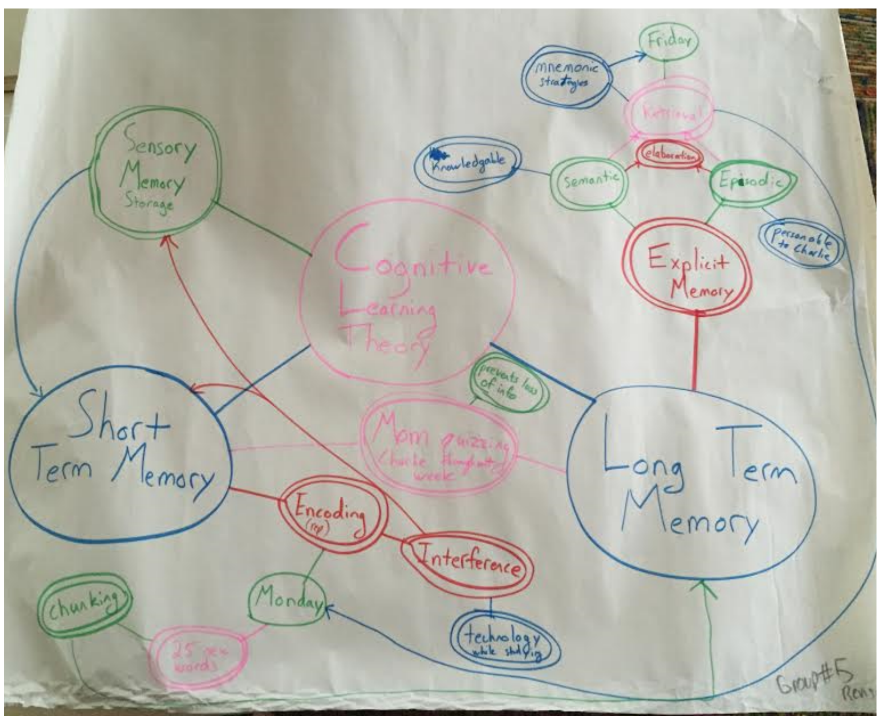




Appendix Z: CLT Pre- and Post- Concept Map Group 4

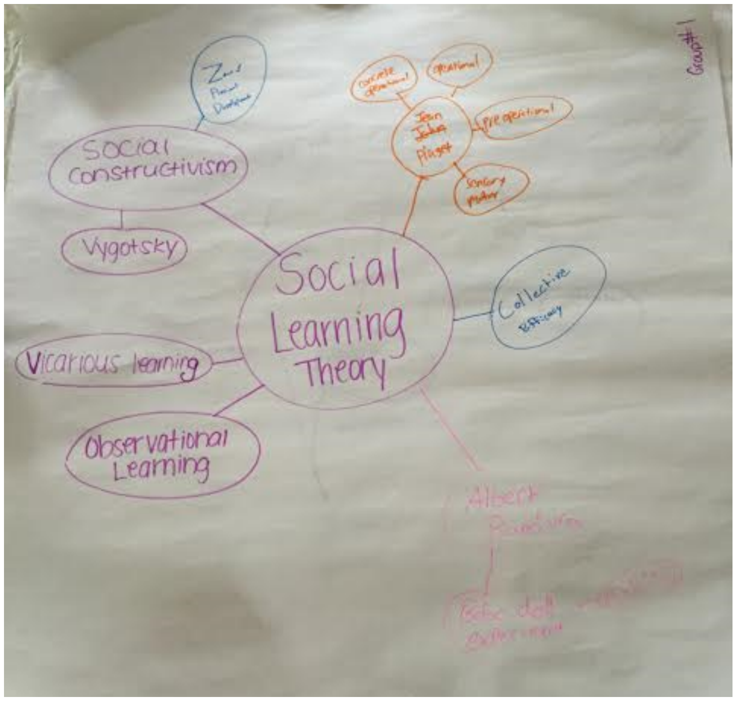
CLT: Group 4 Pre- (above) and Post- (below) Concept Maps

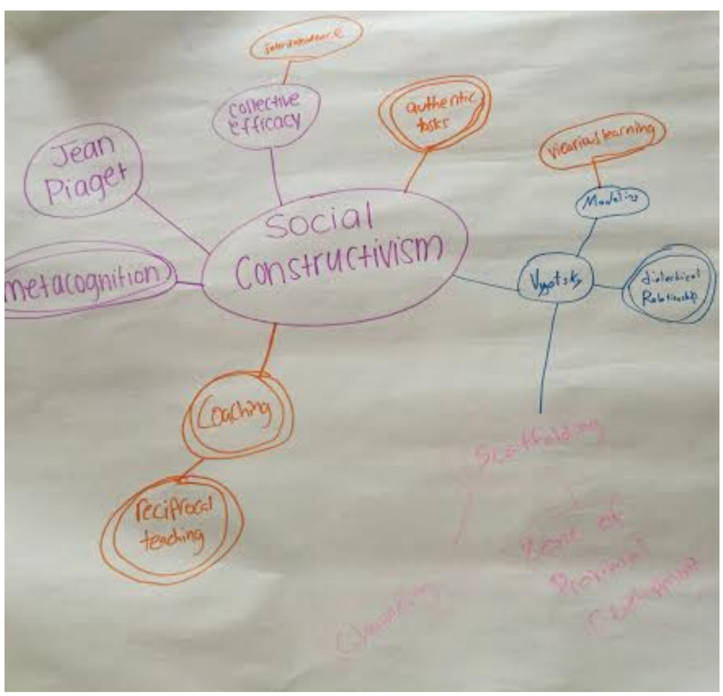




Appendix AA: SCLT Pre- and Post- Concept Map Group 1

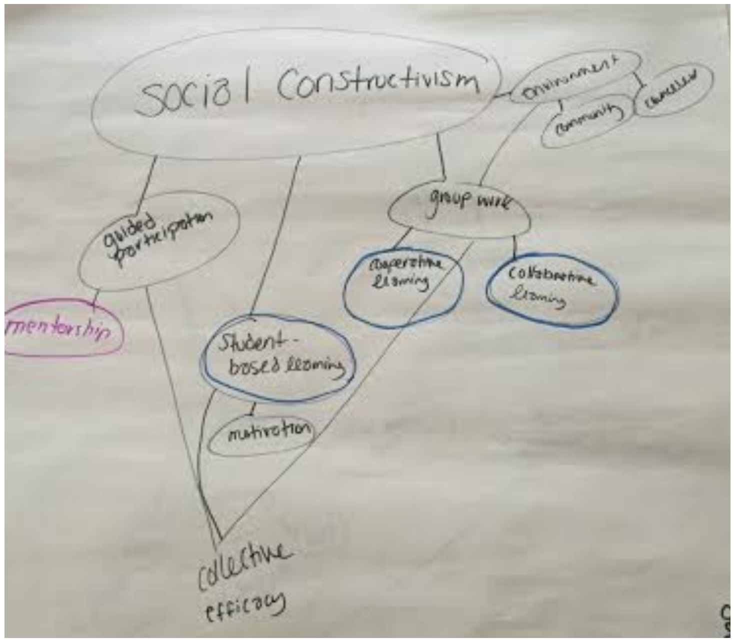
SCLT: Group 1 Pre- (above) and Post- (below) Concept Maps

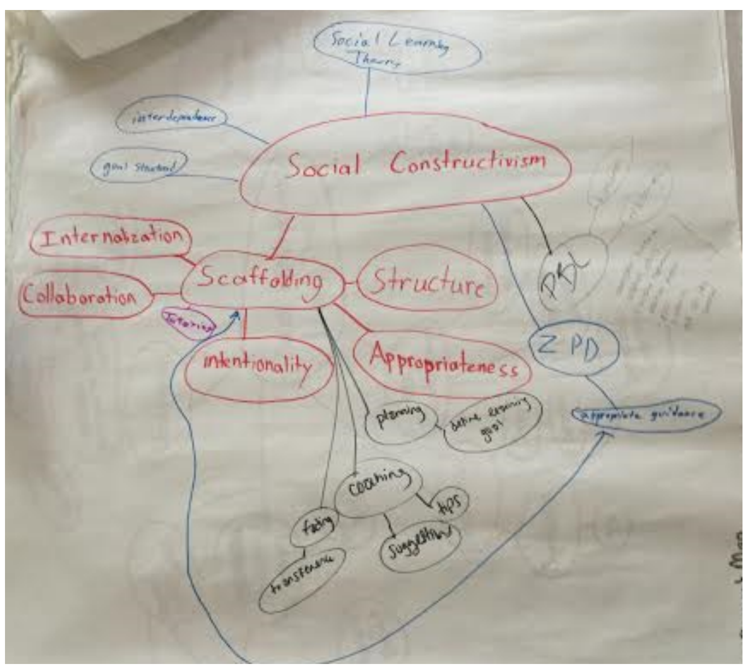




Appendix BB: SCLT Pre- and Post- Concept Map Group 2

SC)LT: Group 2 Pre- (above) and Post- (below) Concept Maps





Appendix CC: SCLT Pre- and Post- Concept Map Group 3.

SCLT: Group 3 Pre- (above) and Post- (below) Concept Maps

Appendix DD: SCLT Pre- and Post- Concept Map Group 4

SCLT: Group 4 Pre- (above) and Post- (below) Concept Maps

Appendix EE: IRB Approval Forms

RUTGERS

Office of Research and Regulatory Affairs
Arts and Sciences IRB
Rutgers, The State University of New Jersey
335 George Street / Liberty Plaza / Suite 3200
New Brunswick, NJ 08901

orra.rutgers.edu/artsci
732-235-9806

August 17, 2015

Suzanne Wichtel
151 Ryders Lane
New Brunswick

P.I. Name: Wichtel
Protocol #: 15-801M

Dear Suzanne Wichtel:

X				
Initial	**Amendment**	**Continuation**	**Continuation w/ Amend**	**Adverse Event**

Protocol Title: "Do Concept Maps Serve as an Appropriate Scaffold for Problem-Based Learning Environments?"

This is to advise you that the above-referenced study has been presented to the Institutional Review Board for the Protection of Human Subjects in Research, and the following action was taken subject to the conditions and explanations provided below:

Approval Date:	7/14/15	**Expiration Date:**	7/13/2016
Expedited Categories:	6,7	**Approved # of Subject(s):**	30

This approval is based on the assumption that the materials you submitted to the Office of Research and Sponsored Programs (ORSP) contain a complete and accurate description of the ways in which human subjects are involved in your research. The following conditions apply:

- **This Approval**-The research will be conducted according to the most recent version of the protocol that was submitted. **This approval is valid ONLY for the dates listed above;**
- **Reporting**-ORSP must be immediately informed of any injuries to subjects that occur and/or problems that arise, in the course of your research;
- **Modifications**-Any proposed changes MUST be submitted to the IRB as an amendment for review and approval prior to implementation;
- **Consent Form(s)**-Each person who signs a consent document will be given a copy of that document, if you are using such documents in your research. The Principal Investigator must retain all signed documents for at least three years after the conclusion of the research;
- **Continuing Review**-You should receive a courtesy e-mail renewal notice for a Request for Continuing Review before the expiration of this project's approval. However, it is <u>your responsibility</u> to ensure that an application for continuing review has been submitted to the IRB for review and approval prior to the expiration date to extend the approval period;

Additional Notes:	▪ **Initial Expedited Approval per 45 CFR 46.110** ▪ **HSCP Certification will no longer be accepted after 7/1/15 (including for anyone previously grandfathered). CITI becomes effective on July 1, 2015 for all Rutgers faculty/staff/students engaged in human subjects research.**

Failure to comply with these conditions will result in withdrawal of this approval.
Please note that the IRB has the authority to observe, or have a third party observe, the consent process or the research itself. The Federal-wide Assurance (FWA) number for the Rutgers University IRB is FWA00003913; this number may be requested on funding applications or by collaborators.

Respectfully yours,

Acting For--
Beverly Tepper, Ph.D.
Professor, Department of Food Science
IRB Chair, Arts and Sciences Institutional Review Board
Rutgers, The State University of New Jersey

cc: Dr. Angela O'Donnell

(MW:nh)

RUTGERS

Office of Research and Regulatory Affairs
Arts and Sciences IRB
Rutgers, The State University of New Jersey
335 George Street / Liberty Plaza / Suite 3200
New Brunswick, NJ 08901
orra.rutgers.edu/artsci
732-235-9806

July 5, 2016

Suzanne Wichtel
151 Ryders Lane
New Brunswick

P.I. Name: Wichtel
Protocol #: 15-801Mx

Dear Suzanne Wichtel:

Initial	Amendment	x Continuation	Continuation w/ Amend	Adverse Event

Protocol Title: "Do Concept Maps Serve as an Appropriate Scaffold for Problem-Based Learning Environments?"

This is to advise you that the above-referenced study has been presented to the Institutional Review Board for the Protection of Human Subjects in Research, and the following action was taken subject to the conditions and explanations provided below:

Approval Date: 7/5/2016 **Expiration Date:** 7/4/2017 **Expedited Category(s):** 8c
Approved # of Subject(s): 30 **Currently Enrolled:** 25

This approval is based on the assumption that the materials you submitted to the Office of Research and Sponsored Programs (ORSP) contain a complete and accurate description of the ways in which human subjects are involved in your research. The following conditions apply:

- **This Approval**-The research will be conducted according to the most recent version of the protocol that was submitted. **This approval is valid ONLY for the dates listed above;**
- **Reporting**-ORSP must be immediately informed of any injuries to subjects that occur and/or problems that arise, in the course of your research;
- **Modifications**-Any proposed changes MUST be submitted to the IRB as an amendment for review and approval prior to implementation;
- **Consent Form(s)**-Each person who signs a consent document will be given a copy of that document, if you are using such documents in your research. The Principal Investigator must retain all signed documents for at least three years after the conclusion of the research;
- **Continuing Review**-You should receive a courtesy e-mail renewal notice for a Request for Continuing Review before the expiration of this project's approval. However, it is your responsibility to ensure that an application for continuing review has been submitted to the IRB for review and approval prior to the expiration date to extend the approval period;

Additional Notes:	• **Continuation Expedited Approval per 45 CFR 46.110** • **IRB Approval has been provided for data analysis only. PI is to contact the IRB prior to the recruitment of additional subjects or further interactions/interventions with subjects;**

Failure to comply with these conditions will result in withdrawal of this approval.
Please note that the IRB has the authority to observe, or have a third party observe, the consent process or the research itself. The Federal-wide Assurance (FWA) number for the Rutgers University IRB is FWA00003913; this number may be requested on funding applications or by collaborators.

Respectfully yours,

Acting For--
Beverly Tepper, Ph.D.
Professor, Department of Food Science
IRB Chair, Arts and Sciences Institutional Review Board
Rutgers, The State University of New Jersey

cc: Dr. Angela O'Donnell
(MW:gj)

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Office of Research and Regulatory Affairs
Arts and Sciences IRB
Rutgers, The State University of New Jersey
335 George Street / Liberty Plaza / Suite 3200
New Brunswick, NJ 08901

orra.rutgers.edu/artsci

732-235-9806

July 5, 2017

Suzanne Wichtel
151 Ryders Lane
New Brunswick
Dear Suzanne Wichtel:

P.I. Name: Wichtel
Protocol #: 15-801Mx

Initial	Amendment	✓ Continuation	Continuation w/ Amend	Adverse Event

Protocol Title: "Do Concept Maps Serve as an Appropriate Scaffold for Problem-Based Learning Environments?"

This is to advise you that the above-referenced study has been presented to the Institutional Review Board for the Protection of Human Subjects in Research, and the following action was taken subject to the conditions and explanations provided below:

Approval Date: 7/3/2017 **Expiration Date:** 7/2/2018
Expedited Category(s): 8c **Approved # of Subject(s):** 30 **Currently Enrolled:** 25

This approval is based on the assumption that the materials you submitted to the Office of Research and Sponsored Programs (ORSP) contain a complete and accurate description of the ways in which human subjects are involved in your research. The following conditions apply:

- **This Approval**-The research will be conducted according to the most recent version of the protocol that was submitted. **This approval is valid ONLY for the dates listed above;**
- **Reporting**-ORSP must be immediately informed of any injuries to subjects that occur and/or problems that arise, in the course of your research;
- **Modifications**-Any proposed changes MUST be submitted to the IRB as an amendment for review and approval prior to implementation;
- **Consent Form(s)**-Each person who signs a consent document will be given a copy of that document, if you are using such documents in your research. The Principal Investigator must retain all signed documents for at least three years after the conclusion of the research;
- **Continuing Review**-You should receive a courtesy e-mail renewal notice for a Request for Continuing Review before the expiration of this project's approval. However, it is your responsibility to ensure that an application for continuing review has been submitted to the IRB for review and approval prior to the expiration date to extend the approval period;

Additional Notes:	▪ **Continuation Expedited Approval per 45 CFR 46.110** ▪ **IRB Approval Has Been Provided For Data Analysis Only. PI Is To Contact The IRB Prior To The Recruitment Of Additional Subjects Or Further Interactions/Interventions With Subjects.**

Failure to comply with these conditions will result in withdrawal of this approval.
Please note that the IRB has the authority to observe, or have a third party observe, the consent process or the research itself. The Federal-wide Assurance (FWA) number for the Rutgers University IRB is FWA00003913; this number may be requested on funding applications or by collaborators.

Respectfully yours,

Acting For--
Beverly Tepper, Ph.D.
Professor, Department of Food Science
IRB Chair, Arts and Sciences Institutional Review Board
Rutgers, The State University of New Jersey

cc: Dr. Angela O'Donnell

(MW:gj)

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Office of Research and Regulatory Affairs
Arts and Sciences IRB
Rutgers, The State University of New Jersey
335 George Street / Liberty Plaza / Suite 3200
New Brunswick, NJ 08901

orra.rutgers.edu/artsci
732-235-2866

June 27, 2018

Suzanne Wichtel
151 Ryders Lane
New Brunswick

P.I. Name: Wichtel
Protocol #: 15-801Mx

Dear Suzanne Wichtel:

Initial	**Amendment**	✓ **Continuation**	**Continuation w/ Amend**	**Adverse Event**

Protocol Title: "Do Concept Maps Serve as an Appropriate Scaffold for Problem-Based Learning Environments?"

This is to advise you that the above-referenced study has been presented to the Institutional Review Board for the Protection of Human Subjects in Research, and the following action was taken subject to the conditions and explanations provided below:

Approval Date: 6/27/2018 **Expiration Date:** 6/26/2019
Expedited Category(s): 8c **Approved # of Subject(s):** 30 **Currently Enrolled:** 25

This approval is based on the assumption that the materials you submitted to the Office of Research and Sponsored Programs (ORSP) contain a complete and accurate description of the ways in which human subjects are involved in your research. The following conditions apply:

- **This Approval-**The research will be conducted according to the most recent version of the protocol that was submitted. **This approval is valid ONLY for the dates listed above;**
- **Reporting-**Reporting- Reporting--ORRA/Arts & Sciences IRB must be immediately informed of any injuries to subjects that occur (within 24 hours) and/or problems (e.g., subject complaints) that arise, in the course of your research within a timely manner (within 5 business days). Visit our website for more information on reportable events, https://orra.rutgers.edu/reportable-events.
- **Modifications-**Any proposed changes MUST be submitted to the IRB as an amendment for review and approval prior to implementation;
- **Consent Form(s)-**Each person who signs a consent document will be given a copy of that document, if you are using such documents in your research. The Principal Investigator must retain all signed documents for at least three years after the conclusion of the research;
- **Continuing Review-**You should receive a courtesy e-mail renewal notice for a Request for Continuing Review before the expiration of this project's approval. However, it is your responsibility to ensure that an application for continuing review has been submitted to the IRB for review and approval prior to the expiration date to extend the approval period;

Additional Notes:	▪ **Continuation Expedited Approval per 45 CFR 46.110** ▪ **IRB Approval Has Been Provided For Data Analysis Only. PI Is To Contact The IRB Prior To The Recruitment Of Additional Subjects Or Further Interactions/Interventions With Subjects.**

Failure to comply with these conditions will result in withdrawal of this approval.
Please note that the IRB has the authority to observe, or have a third party observe, the consent process or the research itself. The Federal-wide Assurance (FWA) number for the Rutgers University IRB is FWA00003913; this number may be requested on funding applications or by collaborators.

Respectfully yours,

Acting For--
Beverly Tepper, Ph.D.
Professor, Department of Food Science
IRB Chair, Arts and Sciences Institutional Review Board
Rutgers, The State University of New Jersey

cc: Dr. Angela O'Donnell

(GJ:mp)