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The Effect of Using Guided Questions and Collaborative Groups for Complex Problem Solving on Performance and Attitude in a Web-Enhanced Learning Environment

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THE EFFECT OF USING GUIDED QUESTIONS AND COLLABORATIVE GROUPS FOR COMPLEX PROBLEM SOLVING ON PERFORMANCE AND ATTITUDE IN A WEB-ENHANCED LEARNING ENVIRONMENT

By

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This dissertation is dedicated to
My Parents,
SungSuk Suh and HeeBok Lee
For their endless prayer, love, and support

And to my Grandmother who is in heaven
For believing in me and showing me a vision
Ever since I was a little girl

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ABSTRACT

Considering the popularity of Web-based instruction (WBI), the research on instructional design and pedagogy for WBI is limited. Specifically, further research on developing learning strategies to improve interaction, cognitive engagement, and motivation for WBI is needed. To enhance complex problem solving in WBI, this study used collaborative groups and guided questions in a hybrid web-enhanced learning environment in which students attended class face-to-face and online. A Problem-Based Learning (PBL) approach was used to design a complex problem scenario for the students. PBL uses authentic, complex problems as the impetus for learning and fosters the acquisition of both disciplinary knowledge and problem-solving skills (Edens, 2000; Flynn & Klein, 2001; Levin, 1995).

The participants were pre-service teachers enrolled in an introductory educational technology course in the College of Education at a large university in the southeastern United States. Students voluntarily participated in the study as an optional part of class activities. The study was designed as a 2 × 2 factorial design. The independent variables used were collaborative groups (presence vs. absence), and guided questions (present vs. absent). The dependent variables of this study were (a) learning outcomes that were determined by measuring students' final products with scoring rubrics, (b) learning processes that were evaluated by observation and review of discussion board postings, and (c) attitudes toward problem solving that were measured by questionnaires and the Instructional Material Motivation Survey (IMMS). Students were engaged in solving a scenario for three weeks and participated in both classroom and online discussion activities. A mixed method study design was applied, which combined an experimental study and qualitative data analysis that included interviews, discussion board message analysis, and observations.

The result of this experimental study showed that the students working individually with guided questions (IQ) significantly outperformed the other treatment groups. It appeared that guided questions were an effective learning strategy for solving complex problems. There were no significant differences for problem-solving attitude among the four groups. The high mean score and the analysis of interviews suggested a ceiling effect for their problem solving attitude. The result from the discussion board message analysis showed a positive relationship between a high level of group discussion engagement and the problem solving outcome. The study implied that, in order for students to gain the full benefits from collaborative group work, the group discussion process should be moderated, especially when students are novice learners in problem solving. Additionally, using guided questions was effective when students worked individually and used the questions as a guideline or checklist. Findings from this study will inform future research efforts on collaborative learning and complex problem solving in web-enhanced educational environments.

CHAPTER I

INTRODUCTION

Context of the Problem

Web-Based Instruction (WBI) is teaching and learning supported by the attributes and resources of the Internet (Khan, 1997; Relan & Gillani, 1997). In other words, WBI indicates instruction that is delivered via the Internet. WBI has become a popular instructional environment and it continues to rapidly expand. According to the National Center for Educational Statistics, enrollment in postsecondary distance education classes nearly doubled between 1995 and 2000 (Waits & Lewis, 2003). WBI allows learners not only to incorporate the ample amount of knowledge and information available online, but enables students and instructors to communicate with each other at a time and place of their own choosing.

The Internet is the most popular delivery medium for distance learning courses at both the undergraduate and graduate levels. In spite of the flexibility of WBI, the results of the National Postsecondary Students Aid study, 1999-2000, which surveyed over 60,000 students, reported that students were less satisfied with their online courses than with traditional coursework (Sikora & Carroll, 2002).

The reasons why some students are less satisfied with distance education are not clear. Middleton (1997) suggests factors, such as feelings of isolation, time management problems, limited accessibility to materials, to other students, and to instructors: can also influence students' perceptions of WBI education in a negative way and result in student frustration and anxiety. According to Hara and Kling (2001) feelings of isolation are a stress factor for online students. In their study, students reported confusion, anxiety, and frustration due to the perceived lack of prompts or clear feedback from the instructor and from ambiguous instructions on the course web site and in e-mail messages from the instructor. The same study reveals that WBI courses that were designed to include effective instructional strategies, such as providing clear instruction and facilitating communications, have been shown to reduce stress levels of students (Hara & Kling, 2001). The factors that contribute to the lower satisfaction with WBI suggest that the attention to WBI course design and instructional strategies may reduce sources of frustration for some students.

There are several types of WBI and one of them is a hybrid WBI. Hybrid WBI combines web-based technologies of distance delivery with face-to-face interaction. The challenge of designing instructional activities in hybrid WBI is recognized (Bourdeau & Wasson, 1998), but formal research on different strategies to promote problem-solving or collaboration is rarely reported.

For any type of WBI course, instructors should carefully consider the following course design elements: (a) presentation of content, (b) instructor-student and student-student interactions, (c) individual and group activities, and (d) assessment of student performance (Rovai, 2004). Among these WBI course design elements, interaction is emphasized most in the literature. For example, Oliver and Omari (1998) stated that the most important component of a successful distance education course is required and consistent interaction. In addition, Berge (1999) mentioned "interaction does not simply occur but must be intentionally designed into the instructional program" (p. 5). As the importance of the social interaction in WBI environments has been increasingly recognized (Hmelo, Guzdial, & Turms, 1998), group problem solving strategies have gained much attention for the design of WBI.

Collaborative problem solving is one of the most common and natural situations in which people accomplish the work of society (Nelson, 1999). In addition, problem solving is regarded as one of the most important cognitive activities in everyday life and one of the primary goals of the education process (Jonassen, 2000; Phye, 2001). Several research studies in the field of education and business have come to recognize the significant learning gains (Stinson & Milter, 1996; Winiecki, 2003) and increased creativity, which develop from learning and working collaboratively in groups or teams (Johnson, Johnson, & Smith, 1991). Research regarding group problem solving in a face-to-face settings has been conducted rigorously (Gabbert, Johnson, & Johnson, 1986; Johnson & Johnson, 1989; Johnson et al., 1991; Lohman & Finkelstein, 2000; Lou, Abrami, & d'Apollonia, 2001). Recently, as using the Internet has become a popular educational tool, the need to examine group problem solving in WBI has emerged.

Vygotsky (1978) presumes that learning and intellectual development are social processes by nature and cannot be fully attained without social interaction within the context. Research in social psychology, for example from Stasser, Kerr, and Davis' study (1989), groups generally outperform individuals, at least the average individual, on many jobs and tasks. Three reasons have been proposed for the observed superiority of groups over the average person, specifically when they are assigned difficult tasks. First, groups do a better job than the average person because they recognize the truth more quickly. Second, groups are better able to reject error (Laughlin, 1980; Laughlin, Vanderstoep, & Hollingshead, 1991). Third, groups have a better, more efficient memory system than do individuals. This permits them to process information more effectively than an average person. However, an individual's covert social characteristics, task difficulty degrees, and different levels of competencies among group members can negatively affect the outcome of collaborative learning. Therefore, these elements should be considered when instructors design collaborative learning activities.

To enhance group problem solving in WBI, a variety of instructional strategies have been suggested such as, problem-based learning, collaborative learning, and the use of guidelines or prompts. Problem-Based Learning (PBL) uses authentic, complex problems as the impetus for learning and fosters the acquisition of both disciplinary knowledge and problem-solving skills (Edens, 2000; Flynn & Klein, 2001; Levin, 1995). PBL is one of the instructional strategies that is often used to help learners enhance interactions and higher thinking by using ill-structured problems that are highly relevant to a subject area, and employ a student-centered approach. PBL has been emphasized for its value to transfer learning into real settings by many researchers (Barrows, 1985; Jonassen, 1997; Savery & Duffy, 1995a, 1995b; J. R. Savery & T. M. Duffy, 1995), and shows positive effects on motivation (Greening, 1998). PBL is used in diverse fields of education, including business schools (Stinson & Milter, 1996), science education (White, 2002), and law schools (Carr, 2001) to promote students' complex problem-solving skills.

Research has investigated outcomes, including comparisons of achievement outcome measures of learners in PBL versus other instructional interventions (Bernstein, Tipping, Bercovitz, & Skinner, 1995; Caplow, Donaldson, Kardash, & Hosokawa, 1997; Stinson & Milter, 1996), the organizational and administrative tasks involved in implementing an innovative curriculum (A. Brown, 1997; Camin, Glicken, Hall, Quarantillo, & Merensten, 2001; Hermann, Rummel, & Spada, 2001), and learners' information-gathering and study patterns (Carr, 2001; Cho & Jonassen, 2002). However, little research has been conducted on structuring the problem-solving process and providing structures or guidelines for learners in the PBL environment.

While the instructional design and organization required to employ PBL approaches in traditional face-to-face environments may be challenging enough on its own, adding online instruction into the course holds even more challenges. Instructors should seek new ways of supporting and structuring their collaborative learning assignments when they put them online (Lohman & Finkelstein, 2000).

One way to support online collaborative problem solving is through the use of guided questions, which are procedural questions embedded within instructional tasks, and provide suggestions, procedures, or hints on how to accomplish the instructional tasks. Guided questions are a type of high-level questioning strategy that is designed to facilitate students' problem-solving processes by asking thought-provoking questions. Instead of suggesting solutions for problem solving, the instructor provides learners prompts with procedures, suggestions, and hints on how to accomplish instructional tasks. This type of guided questioning is used in educational settings to improve learners' cognitive and metacognitive strategies.

Guided question strategies have shown positive effects on higher order thinking in complex problem solving (Collins, 1985; King & Rosenshine, 1994; Young, 1997), but research has not investigated the effect in PBL in online learning environments. Although some current research suggests that using collaborative groups in PBL is more effective than solving problems individually, the research results often fail to show the statistical significance of using collaborative groups in PBL (Chang, Sung, & Lee, 2003; Ge & Land, 2003). The qualitative data analysis from those studies show the influence of using collaborative groups for facilitating metacognition or structuring the problem-solving process. However, the influence was not large enough to draw statistical significances using quantitative data analysis. Questions remain regarding what kind of instructional strategies can support complex problem solving in which students communicate at a distance to solve complex problems.

Purpose of the Study

In this experimental study, the effect of guided questions and collaborative groups for problem solving on performance and attitude were investigated. A PBL strategy was employed in a hybrid Web-enhanced learning environment. Considering the popularity of WBI, the research on instructional design and pedagogy for WBI is limited. Specifically, research into developing learning strategies to improve interaction, cognitive engagement, and motivation in web-based learning is needed.

When instructors teach complex problem-solving, PBL may be a possible solution to motivate students in WBI. One study (Clark, 2003) suggests that students who are in PBL express that they are more motivated because the problems are authentic and relevant. To obtain the effectiveness of PBL, however, there are factors to consider implementing in WBI. Two major factors are using collaborative groups for problem-solving tasks, and providing guidelines to assist students with solving complex problems.

Employment of collaborative groups is encouraged in WBI to enhance interaction among peers. In this study, collaborative groups are employed in a PBL setting to investigate the effect on student problem-solving performance and attitudes in WBI. Current research on collaborative learning in WBI indicates that students may not be ready to solve complex problems without having guidance (Chang et al., 2003; Uribe, Klein, & Sullivan, 2003). On the other hand, to teach complex problem-solving, instructors are not recommended to provide direct solutions of instructional tasks, either (King & Rosenshine, 1994). Therefore, providing guided prompts, cues, or hints to facilitate problem-solving will be appropriate in this research setting. In this study, guided questions are employed in a PBL setting to investigate the effect on student performance and attitude in WBI.

The effects of guided questions and collaborative groups on student performance and attitude are compared with groups – collaborative groups that receive guided questions, collaborative groups which do not receive guided questions, individuals who receive guided questions, and individuals who do not receive guided questions. The following research questions are addressed in this study:

Research Questions

1. How does the use of the guided questions and collaborative groups together affect: problem solving outcomes and attitudes toward problem solving in a web-enhanced learning environment?
2. How does the use of the guided questions affect: problem solving outcomes and attitudes toward problem solving in a web-enhanced learning environment?

3. How does the use of the collaborative groups affect: problem solving outcomes and attitudes toward problem solving in a web-enhanced learning environment?

4. How does the use of the guided questions influence students' processes of developing a solution to a problem-based learning scenario in a web-enhanced learning environment?

5. How does the use of the collaborative groups influence students' processes of developing a solution to a problem-based learning scenario in a web-enhanced learning environment?

Significance of the Study

The research on providing guided questions and using collaborative groups that build structure in Problem-Based Learning (PBL) environments in Web-Based Instruction (WBI) is meaningful because it (a) explores complex problem solving in WBI, (b) investigates the new ways of structuring problem-solving in WBI, (c) examines the effect of using collaborative groups on complex problem-solving, and (d) explores the use of PBL in an educational and technological context where there is a dearth of research.

Studies suggest that due to the complex nature of problems used in PBL, learners are encouraged to reflect on their thoughts during the problem-solving process (Greening, 1998). However, in WBI where learners are physically distant from instructors and peers, the instructional strategies used to stimulate learners' reflection and provide structure to solve complex problems are different from traditional classroom settings. In addition, there are weaker social cues in asynchronous, text-based communication compared to face-to-face communication (Hara & Kling, 2001). Students have to communicate overtly to create a social presence in WBI, whereas students' facial expressions and body language can communicate in a face-to-face class. Studies on using PBL instructional approaches can be found (Caplow et al., 1997; Cockrell, Caplow, & Donaldson, 2000; Hernandez-Serrano & Jonassen, 2003; Mergendoller, Bellisimo, & Maxwell, 2000; Stinson & Milter, 1996), but the effect of using PBL and instructional strategies to facilitate problem-solving in any type of WBI is less known. As a result of this absence of research, questions remain regarding how PBL, problem-solving, and learning strategies can be effectively realized in WBI in which the communication process is different from face-to-face learning environments.

Studies suggest that the guided questioning strategy is effective in facilitating problem-solving (King & Rosenshine, 1994; Young, 1997). Guided questions support a problem-solving structure, which is defining, analyzing, monitoring, and evaluating problems, and those thought-provoking questions are suggested to enhance active learning, which leads to better performance outcomes from learners.

Positive effects on problem-solving have been achieved by using guided questions in face-to-face environments (King & Rosenshine, 1994; Young, 1997). In addition, using collaborative groups for complex problem-solving has been recommended, and it is worthwhile to re-examine their effectiveness in WBI environments. If using guided questions proves effective in supporting the problem-solving process in WBI, instructors will have additional strategies to facilitate PBL in a different setting. It is this author's hope that the findings of this study will contribute to further understanding the facilitation of complex problem solving in WBI.

CHAPTER II

REVIEW OF LITERATURE

Overview

This study will examine the effects of collaborative groups and guided questions for solving problem-based learning scenarios on performance and attitude in a hybrid online learning environment, which is a type of WBI. Distance learning, particularly, web-based learning is getting evermore popular in higher education. Due to the different communication characteristics of WBI, designing effective instruction is a challenging task, especially for complex problem-solving. Considering the rapid growth of web-based learning, effects of using different instructional strategies to improve problem-solving skills are underrepresented.

Collaborative learning and providing guidance are often used as effective strategies for promoting problem-solving processes and outcomes in face-to-face learning environments. However, the effects of collaborative groups and guided questions in WBI are rarely reported. The following literature review will provide the theoretical and practical background for supporting the use of problem-solving strategies in web-based learning environments.

The purposes of this review are to:

1. Define different types of Web-based instruction
2. Establish the need for developing instructional strategies for problem-solving in WBI

3. Establish the effects of Problem-Based Learning on problem-solving
4. Establish the effects of collaborative learning on problem-solving
5. Establish the effects of guided questions on problem-solving
6. Define the emerging issues in facilitating PBL in WBI
7. Describe the hypotheses of this study

Defining Web-Based Instruction

Web-Based Instruction (WBI) is "a hypermedia-based instructional program which utilizes the attributes and resources of the World Wide Web to create a meaningful learning environment where learning is fostered and supported" (Khan, 1997). Relan and Gillami (1997) define WBI as "the application of a repertoire of cognitively oriented instructional strategies within a constructivist and collaborative learning environment, utilizing the attributes and resources of the World Wide Web." Though the above definitions are not similar, there is a common theme, which is that WBI takes advantage of the World Wide Web to deliver instruction.

There are several types of WBI. The first type is designed for totally self-directed learning and there is no instructor facilitation for students. The second type is a fully online course, which has no face-to-face interaction, and an instructor facilitates and guides learning. In this type of WBI, an instructor leads the instruction during the course period of time, usually semester-based. This type of WBI is common in distance learning programs in higher education.

Another type of WBI is a hybrid, which is a combination of traditional face-to-face and online learning. In hybrid WBI, students will meet instructors face-to-face and work on a variety of web-based activities, such as group discussions, or reading and writing assignments. The goal of hybrid courses is to join the best features of in-class teaching with the best features of online learning to promote active independent learning and reduce class seat time (Aycock, Grarnham, & Kaleta, 2002). Using computer-based technologies, instructors use the hybrid model to redesign lecture or labatory content into new online learning activities, such as case studies, tutorials, self-testing exercises, simulations, and online group collaborations.

For any type of WBI course, instructors should carefully consider the following course design elements: (a) presentation of content, (b) instructor-student and student-student interactions, (c) individual and group activities, and (d) assessment of student performance (Rovai, 2004).

Popularity of Web-Based Instruction

The popularity of WBI suggests the need for developing effective instructional design and strategies for several different types of web-based learning environments, which have different attributes from face-to-face environments. The Internet is the most popular delivery medium for distance learning courses in both undergraduate and graduate courses. According to the National Center for Educational Statistics (NCES), of the institutions that offered distance education courses in 2000–2001 (or that planned to offer distance education courses in the next three years), 88 percent indicated plans to start using or increase the number of Internet courses using asynchronous computer-based instruction as a primary mode of instructional delivery for distance education courses (Waits & Lewis, 2003). In addition, 62 percent of institutions indicated that they planned to start using or increase the number of Internet courses using synchronous computer-based instruction as a primary mode of instructional delivery (See table 1). WBI, which is an emerging field in education, is nevertheless, a part of the rapid growth that is the Internet. Reasons for the growth of WBI include economical distribution of instruction (Relan & Gillani, 1997) and freedom to choose time and place to study (Bannan & Milheim, 1997).

Table 1. *Percentage distribution of distance education course offerings*

Primary technology for instructional delivery	Planned level of distance education course offerings			
	Reduce the number	Keep the same number	Start or increase the number	No plans to use the technology
Two-way video with two-way audio (two-way interactive video)	4	13	40	43
One-way video with two-way audio	2	4	12	82
One-way prerecorded video	6	15	23	56
One way live video	1	4	11	84
Two-way audio transmission	1	4	9	86
One-way audio transmission	1	5	13	81
Internet courses using synchronous computer-based instruction	1	4	62	33
Internet courses using asynchronous computer-based instruction	1	6	88	6
CD-ROM	1	8	39	53
Multi made packages	N	2	31	67
Other technologies	N	N	5	94

Note: The question was asked in the present tense rather than referring to 2000-2001, and thus the estimates reflect the responses of the institutions at the time the data were collected in spring 2002. Percentages are based on the estimated 2580 institutions that either offered distance education courses in 2000-2001 (2,320 institutions), or that planned to offer distance education courses in the next three years and could report about their technology plans (490 institutions). Detail may not sum to totals because of rounding. (Waits & Lewis, 2003)

Design issues of Web-Based Instruction

While the Internet provides the functionality of previous technologies, including audio, video, and videoconferencing, it also affords new technological possibilities that are likely to transform many aspects of education. WBI allows learners to not only incorporate the ample amount of knowledge and information available online, but enables students and instructors to communicate with each other at a time and place of their own choosing.

In spite of the flexibility of WBI, the overall satisfaction level with WBI is lower than traditional face to face courses (Sikora & Carroll, 2003). Studies suggest that the causes of the lower satisfaction with WBI are related to instructional design and course implementation issues. WBI presents some unique challenges when it comes to designing and implementing courses. Accommodations for learning styles, hardware and software issues, and availability of instructor support online are all considerations for designing WBI (Rovai, 2003). In addition, due to physical distance, creating interaction is difficult, and students may not have enough chances to learn the important skill of working in teams (Oliver & Omari, 1998). Implementing interactions (Thompson, Martin, Richards, & Branson, 2003), promoting critical thinking in WBI (Chang et al., 2003; Cho & Jonassen, 2002), and providing guidance are other challenges as well.

Although many of the same underlying principles of teaching and learning still apply, web-based courses are qualitatively different from traditional face-to-face courses due to the differences inherent in these styles of communication. As new technology supports WBI, there are several types of communication modes. Students can communicate in a virtual face-to-face environment using an instant messaging system and web-cam. When the text messages are the only way to communicate in WBI, the communication can be divided by two dimensions: (a) synchronous and (b) asynchronous communication. Asynchronous communication allows participants to receive and send messages at times of their own choosing (Winiecki, 2003). Synchronous communication is commonly known as chat and occurs in real time via online. In both manner of communication in WBI, instructors are not able to gauge reactions of students and make small adjustments on the spot just-in-time.

Asynchronous communication is commonly used in WBI and the nature of this type of communication allows students longer reaction and reflection time. Asynchronous communication environments can also reduce tensions by the social presence of other students or an instructor and helps students express their opinions (Oliver & Omari, 1998). However, the absence of body language and facial expression may hinder students from interpreting the nuances of language correctly.

Due to the different nature of communication in WBI, research suggests that instructors should use different instructional design and strategies (Jonassen & Kwon, 2001; Oliver & Omari, 1998; Thompson et al., 2003) for the new instructional media, a computer and the Internet. For example, all aspects of discussion, which are initiation, facilitation, evaluation, and feedback, require different approaches when asynchronous communication is used in WBI.

Designing instruction for solving complex problems is especially difficult in WBI. Designing and implementing instruction to solve ill-structured problems generally requires careful instructional design and strategies to implement in both traditional and web-based learning environments. The reason is that ill-structured problem solving involves working on problems that are complex, ill-defined, open-ended, and real world. Ill-structured problems are similar to those that we encounter in everyday life, in which one or several aspects of the situation is not well specified, the goals are unclear, there is insufficient information to solve them, and there is no right or wrong answer (Chi & Glaser, 1985; Sinnott, 1989; Voss & Post, 1988).

Current research suggests that externalized support or scaffolding is necessary to improve students' ill-structured problem-solving performance (Ge & Land, 2003). To improve instructional design for ill-structured problem-solving in WBI, collaborative learning (Bielaczyc, 2001; Chang et al., 2003; Hermann et al., 2001; Uribe et al., 2003) and scaffolding (Cho & Jonassen, 2002; Land & Zembal-Saul, 2003) are recommended in the professional literature. The next section of this paper discusses how collaborative learning and scaffolding are used to assist ill-structured problem-solving in WBI.

WBI design and Collaborative Learning

Cooperative and collaborative learning are often used interchangeably. According to Panitz (1996), cooperative learning may be thought of as a method while collaborative learning may be thought of as a philosophy. Cooperative learning is highly structured and is effective with respect to well-structured tasks for limited solutions and the acquisition of a well-defined domain of knowledge and skills. On the contrary, collaborative learning is less structured and has ill-structured tasks with flexible solutions and supports the acquisition of an ill-defined domain of knowledge and skills. Because this study is related to solving an ill-structured problem in which the content and task is flexible, a collaborative learning approach is more appropriate than a cooperative learning strategy.

To resolve the WBI design issues and to develop effective online courses and pedagogy, much research has been conducted, especially on using collaborative groups for problem-solving (Bielaczyc, 2001; Chang et al., 2003; Hermann et al., 2001; Uribe et al., 2003). To enhance interaction in WBI, a collaborative learning approach is often suggested (Carr, 2001; Chang et al., 2003; Rovai, 2004; Thompson et al., 2003). For example, collaborative web-based learning (Uribe, et al., 2003, Chang et al., 2003) is employed with PBL, which uses authentic, complex problems as the impetus for learning and fosters the acquisition of both disciplinary knowledge and problem-solving skills (Edens, 2000; Flynn & Klein, 2001; Levin, 1995). A research study (Uribe et al., 2003) used a PBL approach in WBI in which one group of students worked collaboratively communicating via online chat room and the other group of students worked individually. Both groups used the same problem solving scenario. The students discussed given problems and generated solutions. The results indicated that students in the collaborative learning setting generated slightly better solutions than those who did work individually. The research concluded that a lack of directions and guidance in WBI collaborative learning might cause the minimal impact of collaborative learning on student problem-solving performance.

Thompson et al. (2003), employed online role play to promote students' active engagement in asynchronous online discussions. The researchers provided a problem scenario to students and assigned a role to each student in the group. After being assigned a role, students introduced their characters and discussed the issues in the given scenario. The results indicated that student research skills and participation levels increased more than those who did not use the same role play strategy.

WBI design and Scaffolding

Current research suggests providing scaffolding to facilitate student interaction, critical thinking, and problem-solving in WBI. The term scaffolding was first used by Wood, Bruner, and Ross (1976), and they explained scaffolding as when the instructor or a more advanced peer operates a supportive tool for the learners as they construct knowledge. On the other hand, scaffolding instruction as a teaching strategy originates from a developmental psychology basis in Vygotsky's sociocultural theory and his concept of the Zone of Proximal Development (ZPD). Vygotsky (1978) developed the concept of scaffolding and suggested that learning activities should provide adequate challenges to the learner based on his/her current knowledge but at the same time not be so challenging as to be unachievable.

According to Vygotsky (1978), scaffolds serve as aids during the initial learning of a complex skill or cognitive strategy and they provide assistance at critical times in the form of skills, strategies, knowledge, and links that the students use to complete the task. Gradually, the scaffolding is removed as the learner becomes more proficient (Collins, 1985; Greenfield, 1984). In addition, scaffolds are the support from more capable others that allows learners to go to the next step. However, the concept of scaffolding expanded as any manipulation by the system of the task itself, the term scaffolding covers broader areas now.

Scaffolding can be provided by different external agents, for example, instructors, peers, and supplementary materials. In traditional classroom settings, instructors are the most common scaffold for students. However, when instructor support is not available, other forms of scaffolding can be provided by peers or well-designed support materials.

When support materials are used for scaffolding, scaffolds include guidelines, clear objectives, partial solutions or examples, concept maps, or embedded structures in a computer-supported learning environment. In other words, scaffolding covers all types of job aids that support learning. As the computer has become one of the most popular educational mediums, studies examining electronic scaffolds are getting popular as well (Cho & Jonassen, 2002; Land & Zembal-Saul, 2003).

Current research about scaffolding in WBI concentrates on embedded tools in computer-supported instruction. For example, to facilitate asynchronous online discussion, constraint-based scaffolds are used. Constraint-based scaffolds require learners to choose given headers to indicate types of argument in threaded online discussion boards so that learners pre-structure their thoughts before posting their argumentation (Cho & Jonassen, 2002; Jeong, 2003). Also, embedded guidance for learning processes are often used for scaffolding as well. Saye and Brush (2002) used process guidance to provide learners conceptual and strategic road maps that assisted them in understanding the process of disciplined inquiry.

In current research studies (Cho & Jonassen, 2002; Jeong, 2003), scaffolding has become a sense of being auxiliary item or interaction that provides cues and prompts that assist learners to learn. Since scaffolding as a concept has become too general and not very precise to be useful, this study will use more precise terms to specify support items or interaction for learning and will use the term “guided questions”.

Problem Based Learning

Characteristics of PBL

There has been much interest in problem solving areas to support students' problem solving skills. And different instructional approaches and strategies were suggested, such as, using scaffolds, collaborative learning, and a constructivist learning environment. Problem Based Learning (PBL) is one of the instructional approaches that shows positive affect on learners' problem-solving skills (Arts, Gijselaers, & M.S.R., 2002; Caplow et al., 1997; Knowles & Suh, 2005; Stinson & Milter, 1996). PBL is a learning strategy that uses authentic, ill-structured problems that are highly relevant to a subject area, and employ a student-centered approach. Current research has emphasized the value of PBL to the transfer of learning into real settings (Barrows, 1985; Jonassen, 1997; Savery & Duffy, 1995a).

PBL may be one of the most ancient instructional strategies that have been used since the beginning of humankind because it uses authentic settings and scenarios for problem solving, which people always encounter in everyday lives. However, the concept of PBL was articulated as an instructional approach and introduced in 1980s (Barrows, 1985) in medical education to support effective transfer to the medical practice setting. Before introducing PBL, medical school curriculum had focused on presenting information to memorize. Through the use of PBL strategies, students learned how to diagnose and solve medical cases (Barrows & Tamblyn, 1980). Nowadays, PBL is used in diverse fields of education, including business schools (Stinson & Milter, 1996), science education (White, 2002), and law schools (Carr, 2001).

Research suggests that PBL is appropriate when learners are engaged in complex higher-order thinking (Savery & Duffy, 1995). The reason is that the emphasis in PBL is not necessarily on solving the problem, but rather on analyzing and explaining the possible causes and characteristics of a phenomenon (Hmelo & Evensen, 2000), and the underlying principle. Specifically, according to Wood (2003), PBL provides a contextual framework to both anchor prior learning as well as providing a problem-solving model of working that allows new learning to be incorporated over time. Therefore, students may also have a higher probability of being engaged in higher order thinking and problem-solving when they are engaged in PBL activities.

Some researchers describe PBL as a powerful instructional approach that is engaging and that leads to sustained and transferable learning of problem-solving skills (Mergendoller et al., 2000; Stepien, 1993). The PBL approach, however, is not the most effective or efficient solution for delivering verbal information or simple concepts that can be taught without using complex scenarios.

Savery and Duffy (1995) mentioned that PBL is the best example of a constructivist learning environment. Constructivism theory rests on the assumption that knowledge is constructed by learners as they attempt to make sense of their experiences (Driscoll, 2000). Social constructivists, such as Dewey and Vygotsky, view that people learn best not by assimilating what they are told, but rather by a knowledge-construction process with other people (Dewey, 1989; Vygotsky, 1978). In order for individuals to learn how to construct knowledge, it is necessary that the process be modeled and supported in the surrounding community and environment (Jonassen, 1999; Nelson, 1999).

The characteristics of PBL fit very well into constructivism. PBL uses authentic, complex, and ill-structured problems that help learners transfer learning into the real world. In addition, PBL stresses the role of instructors as coaches and facilitators of learning. Students are also responsible for their learning process. Finally, social negotiation and discussion is often employed in PBL for the evolution of knowledge.

PBL is theoretically grounded in broad learning and instructional principles and they are synthesized and discussed in the following section.

1. Provide learners an authentic and complex problem/task.

The main characteristic of PBL is the use of authentic problems to support transfer of knowledge to a real setting. First, a clear scope of a problem should be established before discussing the authentic problem. The problem indicates a wide range of activities with the most critical characteristics being that the activity is a whole task rather than only components of a task and that the task is representative of those the learner will encounter in the world following instruction (Merrill, 2002). Research provides evidence that authentic problems and case descriptions may provide a meaningful context that resembles future professional situations (Brown, Collins, & Duguid, 1989; S. M. Williams, 1992). An important implication of learning in authentic contexts, which offers relevant professional situations, is that it can foster the transfer and application of knowledge in a professional setting (Brown et al., 1989).

Using any kind of authentic problem, however, does not promise to deliver an effective learning outcome. Stinson and Milter (1996) suggest that effective problems should be holistic, mirror professional practice, be ill-structured, and be contemporary to initiate productive group sessions. Savery and Duffy (1995) also made similar arguments, suggesting that students should be engaged in authentic learning activities by confrontation with problems that do not contain pre-specifications. When problems already contain obvious conclusions and interpretations, no higher-order thinking will occur. In conclusion, effective authentic problem descriptions should be real-world problems that do not contain obvious conclusions so that they foster higher order reasoning skills and are relevant for practice and course objectives (Knowles & Suh, 2005). Therefore, instructors of problem-based courses should filter performance problems based on the objectives and goals of the course.

2. Encourage learners to develop ownership for the overall problem/task.

Researchers suggest that learning is promoted when learners are required to use their new knowledge or skills to solve problems (Jonassen, 1999; Nelson, 1999; Savery & Duffy, 1995a, 1995b; J. Savery & T. Duffy, 1995; Schank, Berman, & Macperson, 1999; Schwartz, Lin, Brophy, & Bransford, 1999; van Merrienboer, 1997). Problem-based models in instructional design emphasize the importance of being involved in solving authentic tasks or problems.

To support learners in building ownership, researchers suggest a couple of strategies. Jonassen (1999) stresses that learners assume ownership only if the problems to be solved are interesting, relevant, and engaging. Another way of enhancing ownership is to stimulate students in initiating problems themselves so that the learner adopts the problem generated as their own (Savery & Duffy, 1995a). In the long term, the active learning of PBL promotes the self-directed learning strategies and attitudes needed for lifelong learning (Bereiter & Scardamalia, 1989).

3. Design the learning environment to support reflection and metacognition of learners.

The main goal of using PBL strategies is to support the learner in becoming effective thinkers in a subject area. Immersing learners in complex, open-ended environments requires the use of multiple resources, tools, and perspectives to progressively deepen and refine meaning (Hannafin, Hall, Land, & Hill, 1994) through reflection. According to Piaget (1985), reflection is a dialectical process by which higher-order knowledge is created through the effort to reconcile lower-order elements of knowledge. Helping learners build reflection skills is important because as learners continually revisit and reflect on their understanding, they find opportunities to revise and reassess what they know by moving through various "cycles" of explanation (Schwartz et al., 1999).

In PBL, instructors are expected to stimulate students' process of reflection. To teach skills of analyzing, planning, and developing solutions, instructors must assume the roles of consultant and coach (Savery & Duffy, 1995a). Challenging and guiding students through dialogue is crucial because the dialectical process carried on between instructors and students will eventually be internalized by students, who will then be able to reflect on it independently.

Current research suggests a positive effect of using reflection skills in PBL. A survey about students' perspectives and attitudes regarding PBL indicate students found PBL to help them develop essential communication skills, increase knowledge retention due to opportunities for discussion, and facilitate thinking about the material rather than simply memorizing it (Bernstein et al., 1995). Another study reports that students were able to reflect on and examine their learning strategies when a clear association between the PBL goals and specific instructional strategies employed to accomplish those goals was present (Caplow et al., 1997).

4. Provide opportunities to test and validate ideas through social negotiation.

PBL provides students with strategies to gather knowledge and solve problems both collaboratively and independently. The pioneers of PBL, Barrows and Tamblyn, (1980) suggest that in PBL, it is essential that a problem initiate free inquiry by students working together in a group. PBL creates opportunities for students to work in groups to seek and acquire knowledge for problem solving through the use of authentic problems. When students are engaged in PBL activities, an instructor facilitates group processes, but students generate their own goals, methods, and problem-solving strategies, which should be challenges for them.

5. Conditions for using Problem-based learning.

Not every instructional approach is effective in every learning context. Therefore, it is necessary to determine when a particular approach is the best possible match for the students' needs, the instructor's teaching style, the learning environment, and the instructional goals. It is also important to determine how an instructional approach should be used in a given context.

PBL is not effective in every learning context, though. According to Nelson (1999), collaborative PBL approaches can be most effective when the learning environment is one conducive to collaboration, experimentation, and inquiry, an environment which encourages an open exchange of ideas and information. In addition, the collaborative PBL approach is most appropriate with heuristic and ill-structured tasks, as opposed to procedural tasks (Nelson, 1999). Heuristic tasks are made up of a complex system of knowledge and skills which can be combined in a variety of ways to complete the task successfully. In contrast, procedural tasks, like assembling a bicycle, generally have a more stable and predictable pattern.

Identifying the attributes of PBL and its appropriate learning contexts is important. For example, it is inappropriate to use PBL in some learning contexts where students learn simple concepts or memorize information.

PBL in Web-Based Instruction

Many studies also examined a variety of effects using PBL (Barrows & Mayers, 1993; Greening, 1998; Jonassen, Prevish, Christy, & Stavrulaki, 1999) in traditional face-to-face environments. Getting students to collaborate on problem solving activities in face-to-face environments can be challenging enough, and it is even more difficult in web-based environments. To facilitate web-based PBL, there is a need to provide guided prompts or structure. However, there has been a lack of interest to introduce guidelines or support for web-based problem solving process.

All communication technologies have been used at some point to transmit instruction and support education at a distance. Most recently, computers with web-based connections have gained more attention than other educational technologies such as letters, radio, or television. In addition, major universities are encouraged to open web-based distance learning programs and hybrid classes, which are a combination of face-to-face instruction and web-enhanced instruction.

Current research suggests that PBL can motivate learners in WBI (Clark, 2003; Cockrell et al., 2000; Hmelo & Evensen, 2000; Hmelo, Gotterer, & Bransford, 1997). Research suggests that learners who are in PBL express that they are more motivated because the problems are authentic and relevant (Clark, 2003). The Internet and computer-mediated environments provide various advantages for completing problem-solving tasks. WBI is suitable for PBL because it provides abundant resources that allow learners to do their own planning and present new forms of knowledge that also helps the decision-making process that also helps the decision-making process (Laffey, Tupper, Musser, & Wedman, 1998). In addition, asynchronous communication that occurs in WBI offers learners time to reflect and organize their thoughts. As evidence, Hillman (1999) found that the interaction patterns of computer-mediated groups resembled thoughtful discussions while face-to-face interactions resembled recitations.

In order to cope with social challenges and their educational implications, the use of PBL approaches in higher education has been promoted by many researchers (Bowden & Marton, 1998; Carr, 2001; Savery & Duffy, 1995a; Stinson & Milter, 1996). In addition, some research shows that solving learning tasks or problem assignments together with other students rather than in individual situations has positive effects on students' achievement (Johnson & Johnson, 1989; Slavin, 1997). According to a review of small group learning by Cohen (1994), ill-structured and complex tasks provoked extended elaboration among group members and were associated with 'higher order' conceptual learning.

Collaborative Learning

Theoretical Perspectives on Collaborative Learning

According to sociocultural theory, one's cultural development appears twice, first on the social or interpsychological plane between people and later on the individual or intrapsychological plane within the person (Vygotsky, 1978). The Zone of Proximal Development is a key concept of Vygotsky's theory, and it is defined as "the distance between the actual development level as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance, or in collaboration with more capable peers" (p. 86). Social interactions allow the learner to activate not yet fully developed cognitive functions that enable him or her to perform on a higher cognitive level (Salomon, 1989). Eventually, learning becomes internalized and the learner is able to perform on a higher cognitive level independently as students interact with others.

Roschelle and Teasley (1995) define collaboration as follows, "… a coordinated, synchronous activity that is the result of a continued attempt to construct and maintain a shared conception of a problem" (p. 70). Collaborative learning is defined as "an activity that is undertaken by equal partners who work jointly on the same problem rather than on different components of the problem" (Brandon & Hollingshead, 1999). Therefore, students in collaborative groups are expected to build a shared understanding of a problem and work jointly to solve the problem. Research frequently shows that there are clear educational advantages to be derived from collaborative learning (Brandon & Hollingshead, 1999; Carr, 2001; Nelson, 1999; Oliver & Omari, 1998; Slavin, 1996). Discussion assists students to share knowledge and accompanying interactions often lead to critical thinking (Cho, 2002; Saye & Brush, 2002) and generating solutions (Uribe et al., 2003).

In addition, current research suggests that a collaborative learning environment can positively affect performance on problem-solving skills (Arnseth, Ludvigsen, Wasson, & Morch, 2001; Hmelo et al., 1998; Jonassen, 1999; Nelson, 1999). A number of studies have shown that if students are working in pairs or collaboratively using computer-supported communication, they are less likely to be distracted and more likely to stay engaged in a task, and as a result, spend a longer time on task and become more effective (Brush, 1997; Brush & Saye, 2001; Chen, 1997; Cho & Jonassen, 2002).

Collaborative learning, however, is not appropriate in every learning context. According to social psychology, the effectiveness of group work will vary depending on individuals' competencies in a subject area and social characteristics (Bordens & Horowitz, 2002). A student who is familiar to a certain subject area will actively interact with others and receive benefits through collaborative learning. Alternatively the performance pressure created by working with others in collaborative learning will inhibit his/her performance. In addition, while students work collaboratively, individuals face informal evaluations of each other's performance. Depending on individual social characteristics, some students will appreciate critiques from others and some will be discouraged to perform.

In addition, the type of instructional task is a variable of the collaboration outcome. Crott, Giesel, and Hoffman (1998) suggest in their research on group problem solving that difficult tasks provoke creativity in groups. When faced with a problem that require the group to come up with a number of hypotheses to discover the correct answers, groups more than individuals are able to generate a number of novel explanations (Crott et al., 1998). In conclusion, to maximize the effects of collaborative learning strategies, learner characteristics and the type of instructional tasks should be considered.

Collaborative Learning in Web-Based Instruction

The popularity of WBI has been extending collaborative learning in many ways. A variety of forms of collaborative learning have been adopted in WBI, such as asynchronous discussion, synchronous chatting, and role play. The Internet has made it possible for learners to collaborate beyond the classroom through asynchronous communication. For example, online discussion boards allow students to expand student control over the time expended for collaboration, and increases the time available to read, reflect upon and reply to a message with concrete ideas in writing. In addition, Vygotsky (1978) and Harasim (1990) believe that the change from oral to written communication contributes to learning effectiveness when students have to articulate and elaborate their thinking in writing. Asynchronous online discussion is able to extend the time span for collaboration that may lead to the improvement of in-depth investigation of the collaborative task (Harasim, 1990).

When collaborative learning is employed in WBI environments, several researchers suggest that, some of the communicative disadvantages of the computer-based environment are potentially removed (Klassen & Vogel, 2003; Oliver & Omari, 1998). The reason is that asynchronous online discussion makes students' thinking and problem-solving process visible (Lin, Hmelo, Kinzer, & Secules, 1999), and facilitates delayed reflection (Blumenfeld, Marx, Soloway, & Krajcik, 1996; Scardamalia & Bereiter, 1994). According to Harasim (1990), some students who were not comfortable in classroom collaboration could be very active and engaged online, since there was no time restriction or interruption from more aggressive peers. In online discussion, the less aggressive students have the same time and opportunity to express their thoughts and ideas as much as their more aggressive peers. In this sense, it may help ensure equal opportunity in peer collaboration. Zhang (2004) suggests that it may also help establish positive group dynamics, which is very important for online collaborative learning.

With all the benefits and potentials, collaboration in WBI also brings new challenges to students and instructors. Communication in WBI requires higher writing competency because the lack of non-verbal communication in online discussion makes misunderstanding and miscommunications less detectable. Technology anxiety or frustration hinders students from actively participating in discussions as well (Zhang & Harkness, 2002). In addition, students are expected to be highly self-regulated in WBI settings to work at their pace and meet deadlines (Clark, 2003; Rovai, 2004). Due to these challenges, the literature provides insight into the need for scaffoldings or structures for collaboration in WBI to facilitate discussion and problem-solving processes.

Guided Questions and PBL

Creating learning environments to encourage and support interaction in WBI is a challenging task. Research suggests a number of possible strategies for creating and supporting collaborative learning environments. Open-ended questioning and a variety of learner support are two common strategies that research suggests.

Questioning has been examined by various researchers for its use in facilitating critical thinking and as a monitoring strategy. Rosenshine, Meister, and Chapman (1996) reviewed 26 studies in which students participated in questioning strategies. Most of these studies focused on the use of questions to facilitate comprehension and elaboration of content. Though this study is more interested in the use of questions for guiding problem-solving activities, much can be gained from the research about the use of questioning in aiding comprehension and elaboration.

Using open-ended questions involving authentic contexts can provide further learning support. Such inquiries reflect the way the knowledge will be used in real life and preserve the full context of the situation without fragmentation and decomposition (Brown et al., 1989; J. Brown & Duguid, 1993). These studies suggest that open-ended questions with authentic contexts will support knowledge construction and acquisition through the high levels of interaction and communication among the students.

Guided questioning, which is a type of high-level questioning strategy, is used in educational settings to improve learners' cognitive and metacognitive strategies. In general, guided questions are procedural prompts embedded within instructional tasks. Instead of delivering guidelines for problem solving, the instructor prompts learners with procedures, suggestions, and hints on how to accomplish instructional tasks, such as "what is the justification of your solution? Have you thought about _____aspects of problem?"

Several studies found that the use of guided questions aids the students' comprehension of material more than those who were in unguided questions groups (King, 1991). King and Rosenshine (1994) divided fifth grade students into three treatment groups. One of the groups was trained to ask questions that guided their partner's thinking. The second group was taught to question their partner, but was not provided guidance in questioning. The third group was told to ask and answer each other's question. The study result shows that the group who used the questions that guided their partner's thinking outperformed both the other two groups in solving math problems.

Ge and Land (2003) built on King's work. Undergraduate students in an introductory information science class were divided into four groups with a factorial design of guided questioning vs. unguided questioning interacted with peer vs. individual work. They found that guided questions made a greater impact on student performance than peer interaction.

Davis (2003) examined the impact that varying degrees of questions on science project performance. One group received generic guided questions and the other received more directed and specific guided questions. The results show that students in the generic prompt condition develop more coherent understandings as they work on a complex science project. The researcher pointed that the specific and directed guided questions failed to stimulate student reflection on the process of problem solving. The research also suggests that the effectiveness of guided questions may vary depending on the degree of students' autonomy and prior knowledge in a subject area.

Employing collaborative groups also has been found to work effectively in combination with guided questions. The use of collaborative groups provides a context for students to ask questions, provide explanations, receive elaborations, and construct argumentation. Elaboration, interpretation, explanation, and argumentation are central to the activity of the group, in which learning is supported by other individuals (Webb & Palincsar, 1996).

PBL emphasizes challenging and guiding learners through questioning rather than lecturing. Difficulties can arise in PBL when not enough guidance is provided about the actual problem-solving process. Therefore, providing additional guidelines on how to support learners through the actual problem-solving process is important in PBL instructional settings. King (1991; 1994) argued that questioning facilitates reflection and metacognition, which permit learners to plan, monitor, and evaluate their performances.

The level of cognitive processing stimulated by the questioning procedure depends on the explicitness of the question (Osman & Hannafin, 1994). Highly explicit questions, referred to as low-level questions, focus the learner on question-specific information, such as locating or recalling verbal information. According to Hannafin and Hughes (1986), highly explicit, low-level questions inhibit higher level learning such as problem solving. Research suggests that highly explicit questions over-prompt learners, which means they may provide so much support that the student does little cognitive processing (Rosenshine et al., 1996).

High-level questions, on the other hand, are designed to facilitate and guide the following cognitive and metacognitive activity in learners: deep critical thinking about the materials, activation of relevant prior knowledge, and monitoring of understanding and comprehension (King & Rosenshine, 1994). For example, the high-level questions are used to support learners establishing relationships across concepts, solving problems, applying knowledge, and so forth.

Several studies found that guided questions assist learners to improve both cognitive and metacognitive strategies (Rosenshine et al., 1996; Scardamalia & Bereiter, 1994). As a cognitive strategy, guided questions serve as heuristic guidance to problem solving, not a direct procedure or algorithm to be followed exactly. Research suggests, as a metacognitive strategy, guided questions encourage learners to focus on the learning and thinking process (e.g., choosing and planning what to do, and monitoring what is being done, evaluating progress towards solution) (Artzt & Armour-Thomas, 1992). Although guided questions support learners' cognitive and metacognitive strategies, due to the interchangeability of cognitive and metacognitive function, no questioning procedure can be classified as purely cognitive or purely metacognitive.

The guided questioning strategy will be useful in a web-based problem solving environment where instructors have limitations to provide those questions on time, especially in asynchronous discussions. Through the guided questioning strategy, learners are expected to receive hints on how to solve given problems without receiving too much structure from the question prompts.

Emerging Issues facilitating PBL in WBI

Sociocultural theory supports the role of scaffolding by other peers or instructors in the collaborative learning process to help learners perform on a higher cognitive level. Despite the great possibilities for fostering active collaborative learning in a web-based environment, only limited research has been conducted to improve collaborative learning through a PBL approach in WBI.

Although researchers believe in the positive effect of using PBL on problem-solving, research studies often fail to show significant effects with PBL (Caplow, et al., 1997; Uribe, et al, 2003). The limitations to current study results reveal some future research questions worthwhile of consideration. First, scenarios used for PBL have validity issues. The scenario used for PBL should not so closely relate to students' lives that it will cause lack of motivation to participate in problem-solving. Second, many students are not used to a PBL setting; which requires students to take responsibilities to define, analyze, and solve problems. Solving ill-structured problems without much guidance from instructors can be very challenging to some students. Therefore, Uribe (2003) suggested teaching basic problem solving steps before students engaged in the research study. Third, many students are not used to collaborative settings in WBI. Students need time to adjust to a different communication environment, and the strategies to collaborate in WBI are different from that of face-to-face classroom environments.

Online communication helps students problem-solving through delayed reflection (Lin et al., 1999). On the other hand, students face challenges during web-based problem solving due to characteristics of the online communication, which are different from those of traditional face-to-face classroom settings. To overcome the challenges, employing collaborative groups (Arnseth et al., 2001; Brandon & Hollingshead, 1999; Lin et al., 1999; Nelson, 1999; Uribe et al., 2003) and providing guidance (Cho & Jonassen, 2002; Ge & Land, 2003; Saye & Brush, 2002) are often recommended in current research to improve students problem-solving in WBI environments.

This study will empirically investigate the influence of a printed guide as a form of scaffold that could direct and guide students through the problem-solving activities, which are designed as PBL scenarios, in WBI. It will also investigate student attitude toward problem solving in WBI.

Purpose

The literature review revealed gaps in the existing research on how to support students' motivation toward complex problem solving and facilitate complex problem solving processes in web-enhanced environments. In this experimental study, the effect of using guided questions and collaborative groups for problem solving on performance and attitude was investigated where a problem-based learning strategy was employed in a hybrid Web-enhanced learning environment. Considering the popularity of WBI, the research on instructional design and pedagogy of WBI is limited. One specific area of study which requires more attention is developing learning strategies to improve interaction, cognitive engagement, and motivation in web-based learning.

PBL may be a possible solution to motivate students in WBI. A study (Clark, 2003) suggests that students who are in PBL express that they are more motivated than non-PBL students because the problems are authentic and relevant. Although PBL approaches are beneficial to teach complex problem-solving skills, there are factors to consider when implementing PBL in WBI. Two major factors are: (a) using collaborative groups for problem-solving tasks, and (b) providing guidelines to help students solve complex problems.

Collaborative groups are recommended in WBI to enhance interaction among peers (i.e., Arnseth et al., 2001; Blumenfeld et al., 1996) In this study, collaborative groups were employed in a PBL setting to investigate the effect on student problem-solving performance and attitude in WBI. Current research on collaborative learning in WBI explains that students may not be ready to solve complex problems without having guidance (Chang et al., 2003;

Uribe et al., 2003). On the other hand, to educate complex problem-solving, according to King and Rosenshine (1994), it is not recommended that instructors provide direct solutions. Therefore, providing guided prompts, cues, or hints to facilitate problem-solving without providing too much information was appropriate in this dissertation research setting. Thus, in this study, guided questions were employed in a PBL setting to investigate the effect on student performance and attitude in WBI.

This study compared the effect of guided questions and collaborative groups on student performance and attitude for four groups: (a) collaborative groups that received guided questions, (b) collaborative groups which did not receive guided questions, (c) individuals who received guided questions, and (d) individuals who did not receive guided questions.

Research Questions and Hypotheses

The followings are the research questions and hypotheses related to this study:

Research Question 1

How does the use of the guided questions and collaborative groups together affect: problem solving outcomes and attitudes toward problem solving in a web-enhanced learning environment?

Hypothesis 1.1

It is anticipated that students working as a group and receiving guided questions will create better problem solving outcomes on solving a given problem-based learning scenario than all the other treatment groups.

Hypothesis 1.2

It is anticipated that students working as a group and receiving guided questions will demonstrate better problem-solving attitudes on solving a given problem-based learning scenario than all the other treatment groups.

Rationale for Hypothesis 1.1 and 1.2

Based on the review of previous studies in social psychology (Crott et al., 1998; Bordens, 2002), collaborative learning enhances student learning when they are engaged in complex and challenging tasks. Research suggests that learner characteristics and the nature of instructional tasks should be considered to design collaborative learning activities. In this study, students are assumed to have a similar level of prior knowledge of educational technology and the instructional task will be an ill-structured problem which requires extensive planning and discussion.

To create a learning environment to encourage and support interaction among students and problem-solving, using open-ended questions is suggested in research studies because such inquiries allow students to reflect on the problem-solving process (King, 1994). Guided questioning has been used to improve students' cognitive and metacognitive strategies by providing procedural prompts embedded within instructional tasks (King & Rosenshine, 1994; Young, 1997). These studies suggest that the guidance provided through questions helped students improve reflection and metacognition which leads to better problem-solving outcomes.

Therefore, it is assumed that employing collaborative groups and a guided questioning strategy will create positive impact on the students' problem-solving process and outcome.

Research Question 2

How does the use of the guided questions affect: problem solving outcomes and attitudes toward problem solving in a web-enhanced learning environment?

Hypothesis 2.1.

It is anticipated that students working individually and receiving guided questions will create better final products on solving a given problem-based learning scenario than those who do not receive the guided questions.

Hypothesis 2.2

It is anticipated that students working individually and receiving guided questions will demonstrate better problem-solving skills on solving a given problem-based learning scenario than those who do not receive the guided questions.

Rationale for Hypothesis 2.1 and 2.2

Previous research studies suggest that open-ended questions with authentic contexts will support knowledge construction and acquisition through the high levels of interaction and communication that are encouraged among students (Brown et at., 1989; Brown & Duguid, 1993). Thus, in this study, students who will receive guided prompts that are designed to support students' reflection and metacognition during the problem-solving process will be anticipated to perform better than those who will not receive guided questions.

Research Question 3

How does the use of the collaborative groups affect: problem solving outcomes and attitudes toward problem solving in a web-enhanced learning environment?

Hypothesis 3.1.

It is anticipated that students working as a group and not receiving guided questions will create better final products on solving a given problem-based learning scenario than those who work individually and do not receive guided questions.

Hypothesis 3.2.

It is anticipated that students working as a group and not receiving guided questions will demonstrate better problem-solving skills on solving a given problem-based learning scenario than those who work individually and do not receive guided questions.

Rationale for Hypothesis 3.1 and 3.2

Group collaboration has been used to promote learning in academia by exposing participants to alternative points of view in the context of problem-solving. Research in social psychology suggests that conflicts between peers force them to defend their positions as well as seek additional clarifying information (Bordens & Horowitz, 2002; Hughes, Wickersham, Ryan-Jones, & Smith, 2002). Furthermore, the act of explaining has been shown to benefit both more knowledgeable and less knowledgeable peers (Webb & Palincsar, 1996). Therefore, it is expected that students who will work collaboratively with peers will show better performance than students who work individually.

Research Question 4

How does the use of the guided questions influence students' processes of developing a solution to a problem-based learning scenario in a web-enhanced learning environment?

Research Question 5

How does the use of the collaborative groups influence students' processes of developing a solution to a problem-based learning scenario in a web-enhanced learning environment?

CHAPTER III

METHOD

Context of the Study

The research study was implemented in an introductory course in educational technology at a large university in the southeastern United States. The course requires students to acquire a large amount of computer software literacy (Word, Excel, Powerpoint, Photoshop, Inspiration, and Hyperstudio), together with strategies for integrating technology to support teaching and learning. Approximately 650 students take this course each year.

In the summer of 2004, this course was re-designed in two major ways. The course was redesigned as hybrid in delivery, as a combination of face-to-face meetings with a significant online component. In addition, the course was changed to reduce faculty/staff workload with respect to managing the course. Therefore, the course emphasizes self-regulation to facilitate independent learning. The course is also well-known for its successful, innovative practice with learning activities, and the instructors are experienced with creating, guiding, and moderating a variety of instructional activities in person, as well as online.

Students who enrolled for this course engaged in both face-to-face and online group problem solving throughout the semester. Students and instructors met face-to-face twice per week at a computer lab. Students participated in other activities online in between classes, such as joining in online discussions, studying text books through a textbook website, and participating in web-based training programs.

The hybrid web-enhanced learning environment differs from a fully web-based delivered course because of the instructor's presence in face-to-face sessions. Although students meet the instructor face-to-face, the instructors provide brief lectures about basic concepts and functions of educational software and technology. The roles of the instructor in this course are different from traditional courses where the instructor delivers instruction primarily through lectures. In this course, the instructors' roles as a coach and a facilitator are emphasized, and the instructors facilitate students' independent learning and students take charge in solving ill-structured problems. This study focused on the web-based component of the hybrid course. Therefore, the context of the study represented one type of web-based learning.

Participants

Participants were pre-service teachers enrolled in an introductory course in educational technology (EME2040) in the College of Education at a large university in the southeastern U.S. After receiving degrees in education, these students will serve in a variety of settings, such as elementary schools, high schools, or special education. The age range of the students was 19 to 21 with the exception of one student who was 40 years old. Three students, including the 40 years old student, were excluded due to missing data. The average age of 58 participants was 20.59 (*SD* =2.15). There were four sections of the *Introduction to Educational Technology* course in summer, 2005 and total of 61 students were enrolled.

Approximately 20% of the participants were males and 80% were females. The participants were considered homogeneous regarding their prior experience in the learning task of instructional planning.

Participation in this study was voluntary. To seek students' consent, the purpose of the study, a brief description of the procedures, and the benefits for participating in the study were explained to students before conducting this research. In order to study the students' problem-solving performance in the naturalistic setting of the classroom, the study was incorporated into the current course assignments, with professor approval.

The effect size is calculated using Cohen's (1988) guideline, with a power level of .80, and large effect size of .8 at α-level .05. The minimum sample size is 11 in each treatment. Therefore, this research, which has four different treatment groups, requires at least 44 students total. 61 students enrolled in four different sections and data from 58 students were used due to the missing data from other four participants. Each section was randomly assigned one of four treatments.

Research Design

The Experimental Study Design

The experimental study design employed for this study was a 2 (individual vs. group work) x 2 (presence of guided questions vs. absence of guided questions) factorial design. The primary dependent variables are student performance and attitude resolving a problem-based scenario. Student performance on generating a final work product, an educational webpage, was facilitated by a scoring rubric. The scoring rubric was based on the usability measures designed by a team of researchers from the Learning Systems Institute at the

Florida State University. The measures indicate criteria for well-designed web-based performance support systems. For this study, the usability measures were modified to examine educational web pages. The scoring rubric has five categories: functionality, navigation, visual appeal, requirements, and content (Appendix G). Student attitude towards the problem solving processes were analyzed through two self-reporting questionnaires. One questionnaire asked students about problem-solving strategies and procedures that they used. The other questionnaire was a short version of Instructional Material Motivation Survey (IMMS) (Keller, 1993), which investigates student attitude on problem-solving materials.

In table 2, G stands for group collaboration, I stands for individual work, Q stands for guided questions, and C stands for control group that does not use guided questions.

Table 2. *The Experimental Study Design*

Independent Variables		Collaborative Groups	
		Present	Absent
Guided Questions	Present	Groups with Questions (GQ)	Individuals with Questions (IQ)
	Absent	Groups without Questions (GC)	Individuals without Questions (IC)

Qualitative research was conducted to investigate student problem-solving processes. The qualitative research used a comparative, multiple-case study to analyze discussion postings and open-ended survey questions. Semi-structured interviews were conducted with eight students from four sections for deeper understanding of their problem solving processes. To make sure students worked collaboratively, the researcher and another instructor observed the discussion sessions in the classroom. Problem solving processes were observed by collecting online discussion postings exchanged among group members. For students who worked individually, students were asked to write problem-solving processes and progress on an online discussion board at least once a week.

Independent Variables

Guided Questions

Guided questions were implemented as an independent variable with two levels: guided questions vs. no guided questions. Students who were in two randomly selected treatment groups – GQ and IQ treatment groups – received the guided questions before they engaged in the problem-solving process. The students in GC and IC groups did not receive guided questions. The students who used guided questions were instructed and reminded through emails and online postings to consider the questions to facilitate their problem-solving processes.

The purpose of using guided questions was to provide learners with structure to solve complex ill-structured problems and the cues to monitor their progress. The guided questions have four categories – planning, generating a solution, monitoring, and evaluating – to support students' planning and reflection on the problem-solving process.

The guided questions for the problem solving task were based on previous research and designed by the course instructors who were subject matter experts. The set of guided questions is attached as Appendix D. There are two levels of guided questions: presence and absence.

Collaborative Group

Collaborative group was used as an independent variable with two levels: presence of collaborative group vs. absence of collaborative group. Students in GQ and GC treatment groups worked in groups of three or four people to solve a problem scenario. Other students in the IQ and IC groups worked individually for problem-solving.

The purpose of using a collaborative learning strategy was to facilitate critical-thinking and problem-solving skills through social interaction. According to sociocultural theory, social interaction allows the learners to activate not yet fully developed cognitive functions that enable him or her to perform on a higher cognitive level (Salomon, et al. 1989). Therefore, as learners interact with each other, learning becomes internalized and the learners will be able to achieve higher cognitive levels independently.

Research in social psychology (Bordens & Horowitz, 2002; Crott et al., 1998) suggests that groups generate better solutions than an average individual because groups process information more effectively when conflict arises. For example, when people work with others, in general, they take less time to accept truths and reject errors than when people work individually.

In this study, collaborative groups were engaged in a coordinated activity that was the result of a continued attempt to construct and maintain a shared conception of a problem to generate novel outcomes. The instructor provided guidelines for collaborative learning to ensure each individual in each group participated in group discussion and creating final solution products. The instructor explained the difference between collaborative groups and cooperative groups. In addition, she emphasized the importance of having a common goal and engaging in the project throughout the entire process of developing the final projects.

Dependent Variables

The dependent variables of this study are (a) performance on generating final solutions of an assigned problem scenario and (b) attitude of students toward complex problem solving processes. The effects of collaborative groups and guided questions were not limited to students' final projects. An evaluation that concentrates only on changes in students' final projects provides a potentially distorted picture of the treatments' effectiveness and it is important to look at a variety of aspects of problem solving for better understanding. Collaborative groups and guided questions were designed to influence the (a) quality of the students' final projects, (b) problem-solving process, and (c) the students' attitudes towards problem-solving.

Performance Outcome

In order to measure the performance outcome, students' final projects were scored with the performance scoring rubric (Appendix G). As a final project, students generated web pages, which were linked to instructional modules created in PowerPoint, Word, Excel, and Inspiration software. The final projects represented solutions to the problem scenario.

Once participants submitted their final project files to the course website, instructors were able to download the electronic files. Student performance was measured based on assigned treatment conditions instead of individual learning outcomes. In other words, individual students were measured according to their individual products, while groups were measured as collective units according to their group solution products. This study compares the individual reports and the collective group reports because it focuses, not on measuring individual learning outcomes with different treatments, but rather on student performance in different grouping contexts: individual versus group.

The final projects were graded with the scoring rubric. In this study, the purpose of the scoring rubric was to rate certain dimensions or sub-scales of the quality of students' final products. The scoring rubric was designed based on the evaluation measures that have been used to examine the quality of web-based performance support systems. The evaluation measures were developed by a number of researchers and professors at the Learning Systems Institute at Florida State University. In this study, the measures have been modified to evaluate the educational web pages. There are five categories: (a) requirements, (b) functionality, (c) navigation, (d) content, and (e) visual appeal. A well-developed solution should present the ideas clearly, using proper graphics and other presentation features of software. The possible highest score of this rubric is 50.

Each scale within the rubric was evaluated with work samples from previous classes by two raters, including the researcher and another expert on developing web pages. Training for using this scoring rubric was conducted to test the interrater agreement. The training took approximately four hours and consisted of reviewing each sample product according to the criteria developed for each of the five scales of the scoring rubric. The researcher explained every scale of the scoring rubric (Appendix G) to the other rater with illustrations and examples in order to reach a conceptual consensus on the evaluation between the raters. If necessary, prior to reviewing samples, adjustments were made to the scoring criteria for each sub-scale to improve reliability of the rating. At the conclusion of this discussion and adjustment phase, the researcher and another rater independently scored sample products and compared their ratings for each sub-scale and the total score. If raters found discrepancies, they discussed them. When the two raters graded five sample products, they reached over 90% agreement on their rating for both sub-scales and total score.

The same two raters evaluated the final solution products. Before distributing the final products to another rater, the researcher removed the participants' names from the products and used an ID system, which is the last four digits of their social security number, in their place. Every student product was labeled with an ID number so that the raters would have no information about the treatment conditions (i.e., collaborative groups with the guided questions, collaborative groups without the guided questions, individuals with the guided questions, and individuals without the guided questions) the participants were in when evaluating the products.

Process of Problem-solving

To solve a problem scenario, students wrote online discussion postings or problem-solving progress report. In order to better understand the results of each student's performance on problem-solving, students' online discussion postings and problem-solving strategy essays were evaluated following the quantitative analysis.

The processes of problem-solving were examined with qualitative analysis. Methods of triangulation often involve comparing and integrating data from multiple data sources including qualitative data sources such as interviews and observations. Such efforts flow from a pragmatic approach to mixed methods analysis that assumes potential compatibility and seeks to discover the degree and nature of such compatibility (Tashakkori & Teddlie, 1998). This is seldom straightforward because certain kinds of questions lend themselves to qualitative methods, while other kinds of questions lend themselves to quantitative approaches. Thus it is common that quantitative methods and qualitative methods are used in a complementary fashion to answer different questions that do not easily come together to provide a single, well-integrated picture of the situation (Patton, 2002).

Students received a problem scenario and they posted their reflection of problem-solving strategies on the online discussion board after engaging in creating solutions with PowerPoint, Word, Excel, and Inspiration software applications. Depending on the treatment groups, students in IQ and IC groups posted their reflections on problem-solving processes individually on the documentation board that allowed students to post their documents. Students who were in GQ and GC groups discussed their problem-solving strategies with group members and posted their ideas and opinions on the group discussion board. At the end of the problem-solving session, the postings on the discussion board were analyzed to examine their problem-solving process.

While students were creating final projects in the classroom, one prospective instructor from the same course, who was familiar with the contexts of the projects, observed the students' behaviors. The purpose of the observation was to make sure students who worked as groups worked collaboratively and every group member used software applications to create the final projects.

After students submitted their final products, the instructor conducted semi-structured interviews with selective students to gather more information on their problem-solving processes. The purpose of interviewing was to find out from students those things that cannot be directly observed; feelings, thoughts, and intention could not be observed and interview questions allowed collecting those types of data.

Attitude

After the treatment, two different survey questions were used to measure the students' attitudes: (a) problem-solving process questionnaire and the (b) Instructional Material Motivation Survey (IMMS) (Keller, 1993). To measure students' attitude toward the problem solving process, self-report questionnaires were administered immediately after the problem-solving task. Four different questionnaires were designed, one for each treatment group. The self-report questionnaires focused on student attitude toward problem-solving, group work, guided questions, and the overall strategies used for problem solving.

The self-report questionnaire on problem solving skills (Appendix E) was created based on the work by Uribe (2002) whose research study examined the effect of using case-based and systematic problem solving in a computer-mediated collaborative environment. Due to the similarity of the research focus between Uribe's and this study, the problem-solving attitude survey was adopted and modified for the context of this study. The survey contained 12 Likert-scale items, one multiple choice, and three open-ended questions. Depending on the treatment group, the number of Likert-scale items will vary. For example, students who were assigned in the IQ (individual work and guided questions) treatment group answered questions only related to using guided questions and solving ill-structured questions and did not answer questions about working in a group. Uribe's study reported that Coefficient alpha was computed as an internal consistency estimate of reliability for the Likert scale portion of the survey questionnaire and found to be .83.

The second set of self-reporting questionnaire is to measure students' attitude toward the instructional material, especially their motivational responses. The students' motivational response to the instructional material, which followed PBL approaches in this study, was measured with a modified version of Keller's (1993) IMMS after the treatment. The IMMS

(Appendix F) was developed for assessing the motivational quality of instructional situations. A number of studies have validated the IMMS, primarily with undergraduate students.

The IMMS consists of four different sections; attention, relevance, confidence, and satisfaction. This instrument originally asks students to rate 36 statements in relation to the instructional materials they have just used. Some examples are:

- "These materials are eye-catching." *(Attention)*
- "It is clear to me how the content of this material is related to things I already know." (*Relevance)*
- "As I worked on this lesson, I was confident that I could learn the content." (*Confidence)*
- "Completing the exercises in this lesson gave me a satisfying feeling of accomplishment." (*Satisfaction*)

In this study, the short version of the IMMS, created by the author of the instrument, was used and it contained 12 questions. Participants answered each statement in relation to the instructional materials they had just studied, and indicated how true each statement was. The response scale range from 1 (Not True) to 5 (Very True). Thus, the minimum score on the 12 item survey is 12, and the maximum is 60 with a midpoint of 36. Three of the 12 items were reversed.

Prior reliability testing of the IMMS instrument using Cronbach's alpha measure resulted in all five components (Attention, Relevance, Confidence, Satisfaction subscores, and ARCS total score) greater than .81.

Treatment Materials

The Problem Solving Task Material

An ill-structured, complex, and authentic problem related to the educational setting and the domain of educational technology (Appendix A & B), was used as the instructional material. This material required an extensive planning phase to create a solution. Students in GQ and GC treatment groups worked in small groups within the two sections. Groups of four or five students were randomly assigned. All students had to access the Blackboard course website to discuss a given topic. The electronic discussion board was available for each group to discuss the given scenario with group members. Students were reminded and encouraged to communicate only through the discussion board. After three classroom sessions, each group generated a solution to the problem and developed a final solution product in the computer lab using educational software.

Students in IQ and IC treatment groups worked individually. Instead of engaging in group discussion, students were asked to write approximately 200 word reflective statements about their problem-solving strategies and processes after each class session. Students posted these statements to the online documentation board.

All postings on the online discussion board and the documentation board were collected at the end of the research session and qualitatively evaluated following the quantitative analysis for the deeper understanding of the study results.

Survey Questionnaire

Pre-intervention Assessment

Before the treatment was applied, a survey questionnaire was distributed to collect student background information. The demographic section consisted of four questions, asking the students' major, grade, gender, and age.

Research Procedure

Four primary steps are designed for this study procedure: (1) recruiting participants, (2) assigning participants to different conditions; (3) administrating problem-solving sessions; (4) collecting problem-solving products and survey questionnaires. An outline of the study procedure is diagrammed in Figure 1.

Step 1: Recruit participants

With the permission of the Office of Research, the professor and instructors of the EME 2040, participants were recruited from the EME 2040 sections. The study purpose, description of the task, benefits of the study, and general procedures of the study were explained in the consent form.

Step 2: Assigning participants to different conditions

Each section was randomly assigned one of four different conditions for this study. The task materials were incorporated with the current assignments and curriculum. The study was conducted during the regular class sessions.

Step 3: Administrating problem-solving sessions

The purpose of the problem-solving sessions and criteria of final products were posted online and instructors also explained the criteria in class. The problem-solving on the final project scenario lasted three weeks and students had two class sessions to work on creating solutions. During the problem-solving sessions, group discussion boards were available for students in GQ and GC groups. Students posted ideas and electronic files to share with other group members. Separate group discussion boards were created and each group had their discussion forum.

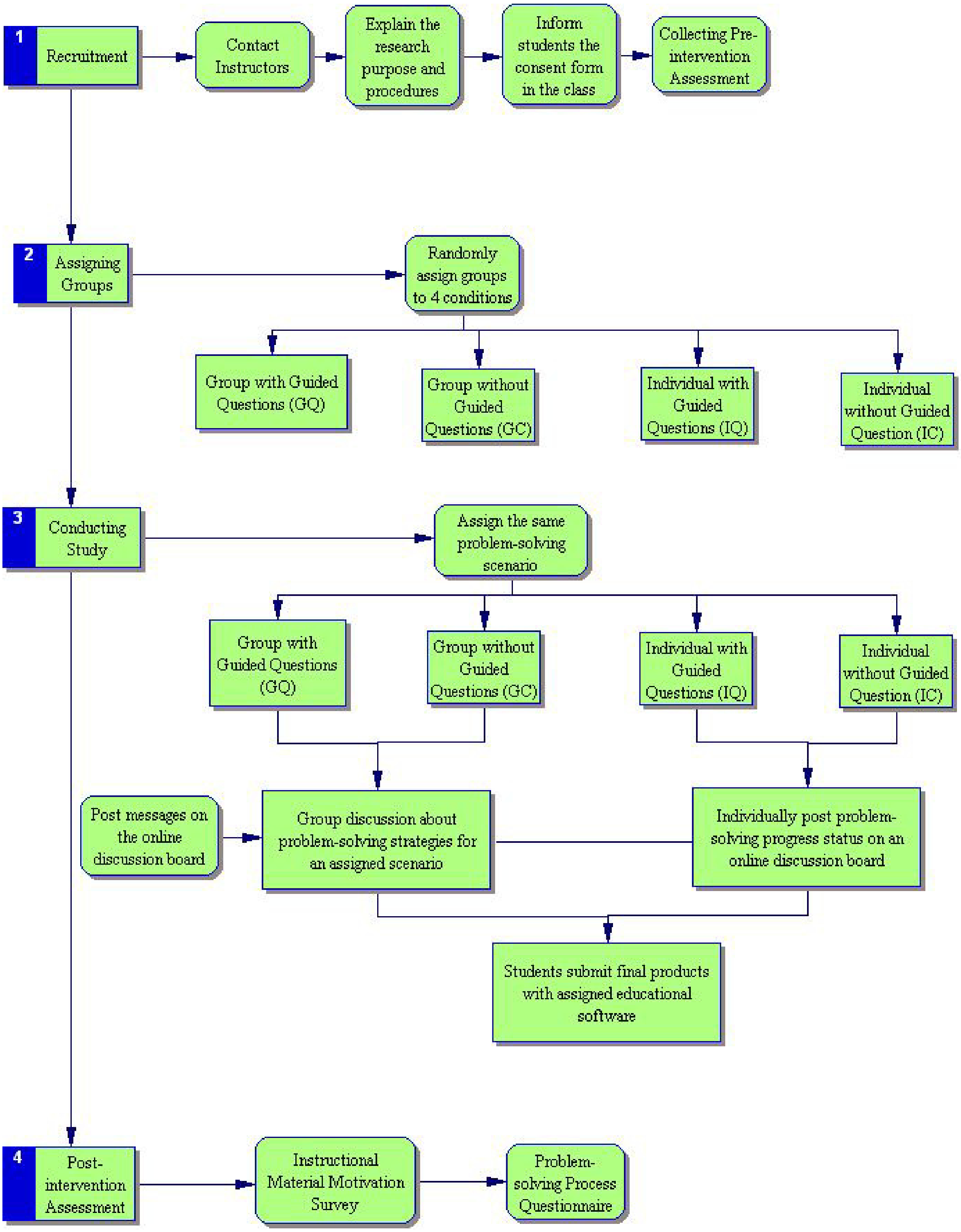

Figure 1. *Implementation procedures for this research*

Students in IQ and IC groups worked individually and posted the reflective problem-solving strategies on the course website at the end of each class session. During the problem-solving session, students in GQ and IQ groups were able to see guided questions on the discussion board and were required to read it before posting their problem-solving strategies or processes. While students were working on their final projects in a computer lab, the instructor assisted students with technical issues.

Step 4: Post-intervention assessment

At the end of the semester, students submitted their products to the instructor. Students' solutions were graded based on the performance scoring rubric (Appendix G). Problem-solving strategies postings and solutions products were collected electronically.

A self-report survey questionnaire and the Instructional Material Motivation Survey (IMMS) were distributed in class immediately after students submitted their products. These questionnaires evaluated students' attitude toward the problem-solving activities.

Data Analysis

Quantitative Data Analysis

A two-way Analysis of Variance (ANOVA) was used to examine the main effects and the interaction hypotheses between the use of guided questions and the collaborative learning strategy on performance and attitude. To answer research questions 1, 2, and 3, inferential statistics were used to compare the performance outcomes among the four different treatment groups.

Qualitative Data Analysis

Research questions 4 and 5 were examined through qualitative data analysis. To achieve an in-depth understanding of the study results, qualitative data analysis was employed after conducting quantitative data analysis. Eight interviews, two classroom observations, and discussion board messages were analyzed. Two students were randomly selected from each treatment group for the semi-structured interviews. The interview questions were prepared to understand the problem solving processes and students' attitudes toward the complex problem solving task. Classroom observations were conducted by two instructors to insure that students worked collaboratively when they initiated the group project in class.

Students used an online discussion board to exchange ideas and report on their problem solving processes, and the messages were collected and analyzed using two different coding sets. The coding sets and the examples for each code are listed in Appendix I. According to the content of the discussion message, the message was coded with one of four codes: (1) defining problem, (2) developing solutions, (3) providing justification/clarification, and (4) monitoring and evaluating solutions. In addition, the messages were coded as substantial and unsubstantial to distinguish messages that simply agree or disagree with a previous message from others.

Qualitative data analysis results were compared against and explained according to the previously developed theories on using guided questions and collaborative learning strategies to support students' problems solving.

This method was selected to answer research questions four and five, which were about investigating the relationship between guided questions and the problem-solving processes as well as the relationship between collaborative learning and problem-solving processes. The results of the qualitative study were triangulated with experimental study results and expected to: (1) confirm the experimental study results; (2) explain or interpret conflicts between hypotheses and findings; and (3) support the understanding of the relationship between collaborative learning and guided questions for problem solving processes.

CHAPTER IV

Results

All of the data that were collected via the method and procedures as specified in Chapter Three are presented in this chapter. This chapter presents the results of the study from the data analysis of the experimental study as well as the qualitative study. The purpose of the experimental study was to study the effects of (a) collaborative groups and (b) guided questions on students' complex problem solving performance. Dependent variables for this study included problem solving outcomes and attitudes. Research questions related to problem solving outcomes and attitudes were analyzed through quantitative data analysis and problem solving processes were analyzed by qualitative data analysis.

The Quantitative Data Results

To answer research questions one, two, and three, the quantitative data were analyzed. An analysis of variance (ANOVA) was employed to analyze how two treatment conditions interact with each other and what effects these interactions have on students' problem solving outcome, attitude, and motivation on problem solving materials. The statistical difference of the four treatment groups were compared and analyzed according to each of the four problem-solving outcomes. The research hypotheses were tested using the results from ANOVA per procedures described by Field (2005). The results of the analysis were used to answer research questions one, two, and three.

Preliminary Data Analysis

A preliminary analysis of the data was conducted to ensure compliance of the assumptions for the parametric statistics used in the study. A review of data revealed no serious violation of the assumptions of normality or homogeneity variance. Examination of scatter plots supported the assumption of normality and revealed linear relationships for all tests. Levene's test of equality of error variances supported the equal variance assumptions for the analyses.

Dependent Variables

Problem solving outcomes and attitude were used to measure the effect of using the guided questions and the collaborative groups.

Problem Solving Outcomes

Problem solving outcomes were measured with the scoring rubric, which has five categories: (a) requirements, (b) functionality, (c) navigation, (d) content, and (e) visual appeal. The possible highest score of this rubric is 50.

Problem Solving Attitude

To measure students' attitude toward the problem solving process, two self-report questionnaires were administered immediately after the problem-solving task: (a) problem-solving process questionnaire and the (b) Instructional Material Motivation Survey (IMMS) (Keller, 1993). The problem-solving processes questionnaire focused on students' attitudes toward problem-solving, group work, guided questions, and the overall strategies used for problem solving. The IMMS measured the students' motivational responses to the instructional materials, including the problem scenario, description of the projects, and guided questions.

Research Questions and Hypotheses

Overview of Data Analysis Results

Table 3 summarizes the descriptive statistics for four problem-solving conditions: (a) groups with the guided questions (GQ), (b) groups with no guided questions (GC), (c) individuals with the guided questions (IQ), and (d) individuals with no guided questions (IC). Students in the IQ condition achieved the best outcomes among four groups with a mean of 49 and standard deviation of 1.7.

Table 3 *Means and Standard Deviations for the Problem Solving Outcome*.

Conditions	Mean	Std. Deviation	N
Individuals with No questions (IC)	46.55	2.98	11
Individuals with Questions (IQ)	49.00	1.70	14
Groups with No Questions (GC)	47.24	.90	17
Groups with Questions (GQ)	46.38	1.31	16
Total	47.29	2.13	58

Table 4 presents the ANOVA results, showing overall differences for the treatment group effect and the outcome variable of problem-solving. The ANOVA results show that there was a significant interaction between collaborative group work and guided questions, F (1, 54) = 12.636, p <.005. In addition, there is a significant main effect for the collaborative group conditions, F (1, 54) = 4.307, $p < 0.05$.

Table 4. *The Results of Analysis of Variance for the Problem Solving Outcomes*

Source	Df	Mean Square	F	*P* value
Corrected Model	3	20.16	6.58	.001
Group	1	13.20	4.30	.043*
Questions	1	8.96	2.92	.093
Group and Questions	1	38.74	12.64	.001*
Error	54	3.07		
Total	58			
Corrected Total	57			

Note: *. The mean difference is significant at the .05 level.

Figure 2 shows the significant main effect for the collaborative group conditions, which means students performed better when they worked individually with guided questions than when they worked individually without guided questions.

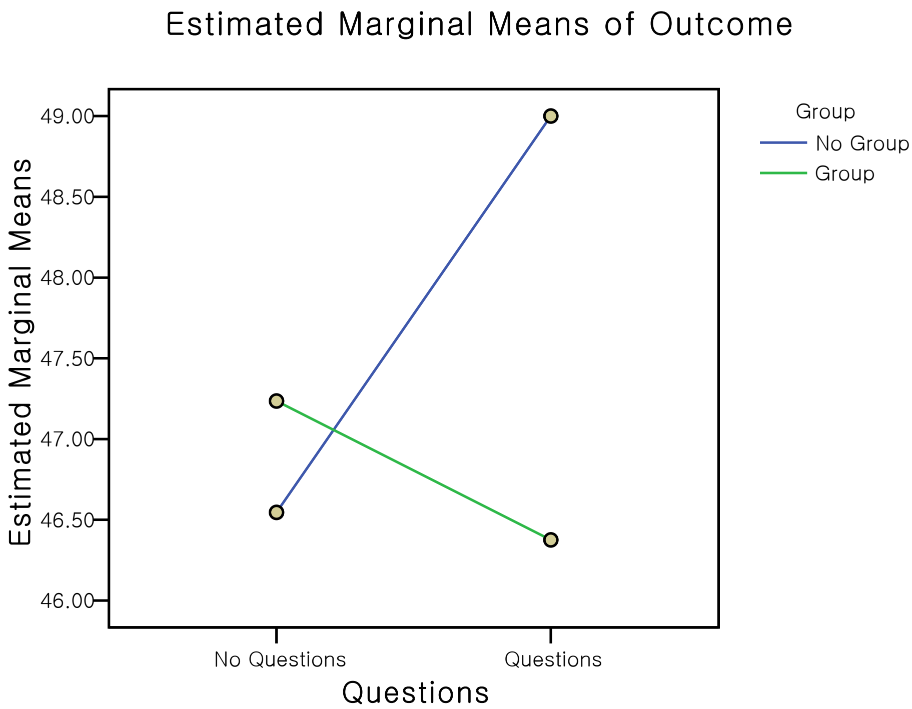

Figure 2: *The result of Analysis of Variance for the Problem Solving Outcomes*

Since the ANOVA results indicated the significant interaction of the two independent variables on problem solving outcome, a post hoc comparison was conducted for further investigation. The post hoc results identified where the significant differences resided. Table 5 summarizes the descriptive statistics for the outcome variable by four treatment groups. The post hoc analysis results show many statistical mean differences among the treatment conditions in the outcome variable.

Table 5 *Summary of Post Hoc comparison*

	Comparison Group	Comparison Group	Mean Difference	*P* value
Tukey HSD	GroupNoQuestion (GC)	GroupQuestion (GQ)	.86	.498
		IndiNoQuestion (IC)	.69	.740
		IndiQuestion (IQ)	-1.76(*)	.035
	GroupQuestion (GQ)	GroupNoQuestion (GC)	-.86	.498
		IndiNoQuestion (IC)	-.17	.995
		IndiQuestion (IQ)	-2.62(*)	.001
	IndiNoQuestion (IC)	GroupNoQuestion (GC)	-.69	.740
		GroupQuestion (GQ)	.170	.995
		IndiQuestion (IQ)	-2.45(*)	.005
	IndiQuestion (IQ)	GroupNoQuestion (GC)	1.76(*)	.035
		GroupQuestion (GQ)	2.63(*)	.001
		IndiNoQuestion (IC)	2.45(*)	.005

Note:

(a) Note: * The mean difference is significant at the .05 level.

(b) The mean difference shown in this table is the subtraction of the second condition (on the right) from the first condition.

The group that worked individually with guided questions (Mean = 49, SD = 1.7) significantly outperformed the other treatment groups (Group with No Questions, Group with Questions, Individuals with No Questions), with a mean difference of 1.76, 2.63, and 2.45 respectively. The IQ treatment group significantly outperformed GQ treatment group with the mean difference 2.63. IQ group significantly performed better than GC group with the mean difference of 1.76.

Problem-solving process questionnaire: The results of the ANOVA did not reveal significant effects for problem solving attitude measured by the problem-solving process questionnaire F (1, 54) = 1.804, p = .185. According to the means of the final project outcomes, which table 6 presents, the IC group has the highest mean 56.2 (SD = 5.5) and the GC has the second highest mean 52.7 (SD = 7.5).

Table 6: *Means and Standard Deviations for the Problem Solving Process Attitudes*

Conditions	Mean	Std. Deviation	N
IC	56.18	5.55	11
IQ	50.86	4.05	14
GC	52.68	7.05	17
GQ	51.88	7.49	16
Total	52.68	6.42	58

Instructional Material Motivation Survey: The students' motivational responses to the instructional materials including the problem scenario, description of the projects, and guided questions were measured by the IMMS. The results of the ANOVA did not reveal significant effects for students' motivational responses measured by the IMMS F (3, 54) = 2.184, p = .1. Table 7 presents the means and standard deviations of the IMMS scores. The descriptive statistics revealed that GC group had the highest mean 52.06 (SD = 6.69) and IQ group had the lowest mean 46.35 (SD = 7.5).

Table 7. *Means and Standard Deviations for the Instructional Material Motivation Survey*

Conditions	Mean	Std. Deviation	N
IC	51.73	6.62	11
IQ	46.36	7.46	14
GC	52.06	6.69	17
GQ	51.50	6.88	16
Total	50.47	7.14	58

Research Question 1

How does the use of the guided questions and collaborative groups together affect: problem solving outcomes and attitudes toward problem solving in a web-enhanced learning environment?

Hypothesis 1.1

It is anticipated that students working as a group and receiving guided questions will create better problem solving outcomes on solving a given problem-based learning scenario than all the other treatment groups.

Hypothesis 1.2

It is anticipated that students working as a group and receiving guided questions will demonstrate better problem-solving attitudes on solving a given problem-based learning scenario than all the other treatment groups.

The analysis of variance results revealed that there is a significant interaction between using collaborative groups and the guided questions ($p<.05$). However, the Post Hoc analysis results did not support hypothesis 1.1, showing that students working individually with guided questions performed the better (Mean = 49, SD = 1.71) than other treatment groups. For the hypothesis 1.2, the ANOVA result revealed that there was no significant interaction for attitude and the hypothesis 1.2 was not supported at the .05 level.

Research Question 2

How does the use of the guided questions affect: problem solving outcomes and attitudes toward problem solving in a web-enhanced learning environment?

Hypothesis 2.1.

It is anticipated that students working individually and receiving guided questions will create better final products on solving a given problem-based learning scenario than those who do not receive the guided questions.

Hypothesis 2.2

It is anticipated that students working individually and receiving guided questions will demonstrate better problem-solving skills on solving a given problem-based learning scenario than those who do not receive the guided questions.

The hypothesis 2.1 was supported at the .05 level. The students working individually and receiving guided questions performed significantly better than those who worked individually without guided questions (Table 5). The mean difference between the two groups is 2.45 and p value is .005. However, there is no significant statistical difference on using the guided questions for students' problem-solving attitudes, which did not support the hypothesis 2.2.

Research Question 3

How does the use of the collaborative groups affect: problem solving outcomes and attitudes toward problem solving in a web-enhanced learning environment?

Hypothesis 3.1.

It is anticipated that students working as a group and not receiving guided questions will create better final products on solving a given problem-based learning scenario than those who work individually and do not receive guided questions.

Hypothesis 3.2.

It is anticipated that students working as a group and not receiving guided questions will demonstrate better problem-solving skills on solving a given problem-based learning scenario than those who work individually and do not receive guided questions.

The hypothesis 3.1 was not supported at the.05 level. The students working as a group received better scores on average for their projects, but the difference is not statistically significant. The hypothesis 3.2 was not supported at the .05 level.

Qualitative Data Analysis

Two observations, discussion board postings, and eight interviews were analyzed for a better understanding of students' problem-solving processes. The purpose of observation was to examine whether students collaboratively participated in the group work or not. Therefore observations were conducted in both the GQ and GC treatment groups.

Classroom Observation

The purpose of the observations was to ensure that students worked collaboratively when they planned and developed their final project. Therefore, two instructors observed the GQ and GC treatment groups. Due to the heavy workload of this project, the project was introduced three weeks before the submission deadline. Students had two full classroom sessions to work on the project: one in the 4^{th} week and the other in the 6^{th} week of the semester.

The observations revealed that students were actively engaged in the classroom group discussion. Commenting on the observations, one of the observers notes: "I do not observe any student who dominates the group discussion. Instead, all students are participating and sharing ideas for their final projects." In addition, students were focused on their discussion topics during the 45-minute-long discussion session: "Students were very good at focusing on their topic and not discussing any off-topics. For about 30 minutes, students discuss a lot and the classroom is a bit loud from their talking. After the first 30 minutes of the discussion, students start writing down what they decided on the online discussion board."

After the first group discussion in the classroom, students participated in online discussions on the course website to exchange ideas and give feedback to each other.

Discussion Board Postings

The students in the GQ and GC treatment groups participated in their group discussion forums for three weeks to work on the project together. The students in IQ and IC treatment groups posted their individual progress on the documentation board, and the students did not discuss with each other as those who were in GQ and GC conditions.

Table 8 presents the quantitative levels of the students' discussion board participation. Students in the GQ condition posted on average 3.1 messages per person versus the GC group which posted an average of 8.9 messages. Students in IQ condition posted 3 messages and the IC group posted 4.9 messages on average. The distribution of posts was not equal among students, with some submitting as many as 11 messages to a discussion board and others not posting at all.

The number of total threads exhibited indicators of the depth of the discussion, and the group forums from GC condition showed many more threads than those in the GQ condition. The postings from the GC condition revealed the evidence that students discussed certain issues, exchanged feedback, and organized their project through the online discussion board. For example, students actively used the discussion board to decide on the topic for the project. A student from the GC condition posted, "Any idea? A joint research paper between an English and a history class. The paper is the English assignment and the topic has to be a historical event or person." In addition, students used the discussion board to check out group member's progress and clarify assigned requirements.

Table 8. *Breakdown of Discussion Board Participation*

Conditions	Total Posts	Students Posts	Instructor Posts	Total Threads
Groups with Guided Questions (GQ)				
Group 1	21	20	1	3
Group 2	15	14	1	4
Group3	8	6	2	2
Group 4	6	4	2	1

Table 8. Continued

Groups without Guided Questions (GC)				
Group 1	49	49	0	15
Group 2	38	38	0	11
Group3	41	40	1	10
Group 4	24	24	0	7
Individuals with Guided Questions (IQ)	43	43	0	N/A
Individuals without Guided Questions (IC)	54	51	3	N/A

Group 1 from the GC condition, Posted by AD on June 6 2005

> Where is everyone on their individual projects? I think the web page should include hyperlinks to all of the pieces of the projects? If everyone agrees than you can email me your piece and I can attach it to the final project. Also I was wondering exactly what elements I should incorporate into the web page. …. What does everyone think of that? Just let me know. Also do we all want to meet after class or this weekend to finish up the project or would everyone rather work solely through black board.

Another student replied to the message above:

> That is what the instructor said to do, so you're definitely on the right track (making hyperlinks on the website) :). I have a rough draft for my section. I'm going to finish it completely this week... by Thursday at the latest. :)

It was clear that students in the GC condition used the online discussion board effectively. Also, this condition group worked mostly online and almost finished their final projects before the last class session

For the GQ condition's discussion boards, the instructor posted a set of the guided questions as the first message. In class, students read the guided questions as the instructor introduced the project to them. Students were then engaged in face-to-face discussion for approximately 45 minutes and then used the discussion board following that class. Unlike the GC group, students in the GQ group started the discussion with their concrete plan for the project:

Group 3 from the GC condition, Posted by SW on May 25 2005

> Our group is going to make an electronic brochure that will enable the students to utilize the Internet and other references other than books. It will include frequently asked questions and answers, budgeting tools, and a 'how to sell' parents feature. In our MS word we will have general information, Q and A, and testimonials. Our inspiration site will include a mapped out design for the parents to view all the benefits of studying abroad. The power point will discuss advantages, disadvantages, and general information about studying abroad. The excel will profile the finances and budgeting.
> GV- MS word , SW- Inspiration, MI – Excel, DL - Power Point
> We will all be working on the web page together.

Once they posted their initial plans, students in the GQ condition did not enthusiastically participate in the discussion board. There are only a couple of discussion threads in each group discussion forum and none of the threads evolved beyond the basic message-response level (two levels deep). One of the groups discussed the face-to-face meeting time on the discussion board and did not exchange much information after that. When the GQ students showed up for the last class session for the project, most of them were not ready to complete the project in the classroom and some students had not finished their individual tasks due to misunderstandings and miscommunications.

Table 9. *The Result of Discussion Board Message Analysis*

Condition	**Code**	**Number**							
GQ	Code	Group 1		Group2		Group3		Group4	
	1	2	9.5%	5	33%	3	50%	1	25%
	2	18	85.7%	6	40%	3	50%	3	75%
	3	1	4.8%	4	27%	0	0%	0	0%
	4	0	0.0%	0	0%	0	0%	0	0%
	S	15	71.4%	12	80%	6	100%	4	100%
	U	6	28.6%	3	20%	0	0%	0	0%
	Total	21		15		6		4	
GC	Code	Group 1		Group2		Group3		Group4	
	1	7	14.3%	7	18.4%	13	31.7%	18	75.0%
	2	29	59.2%	26	68.4%	23	56.1%	4	16.7%
	3	3	6.1%	2	5.3%	1	2.4%	2	8.3%
	4	10	20.4%	3	7.9%	4	9.8%	0	0.0%
	S	37	75.5%	27	71.1%	26	63.4%	14	58.3%
	U	12	24.5%	11	28.9%	15	36.6%	10	41.7%
	Total	49		38		41		24	
IQ	Code	Number				IC	Code	Number	
	1	17	31.5%				1	13	30.2%
	2	24	44.4%				2	19	44.2%
	3	1	1.9%				3	4	9.3%
	4	12	22.2%				4	7	16.3%
	S	54	100.0%				S	41	95.3%
	U	0	0.0%				U	2	4.7%
	Total	54					Total	43	

Note: 1 = Defining a problem
2= Developing solutions
3= Providing justification/clarification
4= Monitoring and evaluating solutions
S= Substantial message
U=Unsubstantial message

The message analysis results showed that IQ students, who significantly outperformed the other three groups, wrote more about defining problems and evaluating solutions than any other group. On the contrary, none of the students from the GQ condition, which has the lowest performance outcome mean score, posted a message regarding evaluating their solutions. Compared to GQ, GC posted approximately three times more messages on the discussion board and they exchanged feedback on drafts while they worked on solutions. For example, one student from GQ condition commented on another student's question about developing a grade book:

We need to be specific for the final grade. For example, on the history side: length = 10%, clearly defined argument= 25%, or on the English side: grammar = 10%, Citations=10%. These are just examples but do you know what I mean?

Students in the IQ condition reflected on their problem solving processes on the discussion board.

A student from the IQ condition, Posted by DM on May 29 2005

My final project is complete. This is one project that I have learned a great deal from. It has taught me how to use different computer software and I will be able to use this information. When I become a teacher, I am going to create a website for my students. And When I am a teacher and this final project has taught me how to do that.

Another student in the IQ condition stated more specifically what the barrier of the problem solving process was:

I was able to go a lot faster once I stopped thinking about how cool I wanted to make it looked and started to focus on getting the information in and then formatting later on. It seems that I am doing my own research paper, rather than setting out guidelines for their research paper. My favorite part was working on the webpage as well as Inspiration.

Semi-structured Interview

The researcher conducted eight semi-structured interviews right after the final classroom session. The questions are listed in Appendix H. Two students were randomly selected from each condition, and each interview lasted approximately 5 minutes. All students who engaged in group work showed that they were satisfied with their outcome as a team and enjoyed the collaboration. One student stated enthusiastically: “Group work was the best part of the final project. I really enjoyed the group members and we all did the project together. It was a lot of fun.”

Four of the interviewed students had used guided questions. Those students expressed two different feelings about using the guided questions. A student who was in the IQ group mentioned, “The guided questions and discussion board were nice because often times you think about stuff but you forget later on. I actually wrote down what I was going to do for the final project and that was helpful.” Another student said, “Guided questions were helpful to make an outline for the final project.” Two students, however, did not make much use of the guided questions. For example, one student in the IQ group said, “Guided Questions? Nah. I didn’t really read it. It wasn’t that helpful to me.

Regarding the use of discussion board, students found it useful to self-regulate themselves: “Discussion postings definitely prevented me from procrastination.” For students who individually worked, the discussion board was a place to check whether they were on the right track by looking at other students’ postings about their progress.

According to the interviews, students had positive attitudes toward the nature of the project and materials. All eight students said that they liked the final project because they had a chance to apply all the skills and knowledge acquired throughout the semester. One of the interviewees mentioned that she had feelings of achievement and pride after creating the final project, which was creating an educational website.

Students also pointed out some of the points for future improvement. Most students wished they had been allowed more classroom time to work on their project. Two students mentioned that some of the project descriptions were confusing, especially with the use of the term *product*, which signified for them something tangible, when the instructor simply meant a final outcome of the project. One student stated that she wanted more feedback from the instructor on the discussion board.

Research Question 4

How does the use of the guided questions influence students' process of developing a solution to a problem-based learning scenario in a web-enhanced learning environment*?*

The analysis of the discussion board postings showed that students who used guided questions posted initial messages that are more detailed and organized than those who did not use the guided questions. In addition, they mentioned more about deciding about content and how they were going to organize the final project, which is developing an educational website. On the other hand, students who did not use the guided questions showed from their postings that they planned the final projects based on the grading criteria and minimum requirements. Therefore, the messages did not include many thoughts about how the final project would be presented as a whole. For example, they stated who was going to work on a specific part of the project and how many slides or files they were going to create.

Research Question 5

How does the use of the collaborative groups influence students' process of developing a solution to a problem-based learning scenario in a web-enhanced learning environment*?*

The quantitative data revealed that there was no significant difference of using collaborative groups in terms of their final outcomes. The qualitative data illustrated that students in the both collaborative groups and individual work conditions followed similar problem-solving steps. Students started developing a solution by choosing a main idea and topics for the project. Most students mentioned that they spent some time brainstorming ideas. Some students wrote outlines for themselves and posted them on the discussion board. Once they had developed a good schema of the final project, they moved on to planning the smaller portions of the project.

There were differences between the treatment groups when the students were seeking help while developing the website for the final project. Students who worked in groups tended to ask questions to each other before they carefully read the instruction and requirements. For some groups, students misunderstood the requirements and they had to work on a missed portion of the project at the last minute. On the contrary, students who worked individually spent more time reading the instructions for the project and then asked questions to either other students or the instructor.

The classroom observation revealed that those who worked individually paid more attention when the instructor explained about the project. When students were engaged in group work, they were easily distracted by other group members. As a result, they tended to ask questions about the information that the instructor just explained in front of the class.

CHAPTER 5

DISCUSSION

Overview

The primary purposes of this chapter are to discuss and offer explanations for the findings reported in chapter four, offer reasonable conclusions for the overall investigation, and to make recommendations for future research and practice.

The main purpose of this study was to examine the benefits of collaborative groups and using guided questions to solve a complex problem in a web-enhanced learning environment. The secondary purpose was to investigate the relative effects of these two approaches on individual learner's attitudes and perceptions on the problem-solving process. The findings related to the five research questions are summarized below, and followed by discussions of the implications for instruction, instructional design, and future research.

Discussion

1. Does the use of the guided questions and the collaborative groups together have effects on problem solving in WBI on attitude toward problem solving and academic performance?

The finding from the ANOVA showed that there was statistically significant interaction of the guided questions and collaborative groups on problem solving outcomes.

However, there was no statistically significant mean difference for using them on students' performance and attitude toward complex problem-solving. Based on the study results, the students who worked in groups without the guided question (GC) performed better than those who worked in groups with the guided questions (GQ). In addition, students who worked individually with the guided questions performed the best.

The first possible reason of this study result might be explained by the level of engagement of group discussion. The qualitative data analysis shows that the students in GQ group did not use the online discussion board to exchange ideas and feedback while they were working on the project. According to the message postings, the students in GQ condition participated in the discussion in the planning phase and they did not collaborate online when they developed their solutions, which were educational websites. On the other hand, students in GC group used the discussion board extensively throughout the planning and development phase of the project.

Another possibility of this study result might be related to the poor time management for their projects. Students in both GQ and GC group divided the project into individual portions for the project. While GC condition frequently checked other members' progress and clarified unclear points, GQ condition did not collaborate until the last minute. As a result, students in GQ group experienced confusion and conflicts among group members in the last classroom session.

It is of interest that there was such noticeable difference in the participation styles between the students in the GQ and GC conditions. The different group dynamics can be explained with the qualitative data. According to the observations, students in the GQ groups are generally outgoing, and the group members became friends as soon as they started the group work in class. The close bond among the group members could have enhanced their performance. However, in this case, students were distracted in the classroom because they chatted about off-the-project issues. On the other hand, students in the GC condition did not show much of connection among group members at the first group project session. Instead, the GC students were more task-oriented and took the final project more seriously.

2. Does the use of the guided questions have effects on problem solving in WBI on attitude toward problem solving and academic performance?

According to the study results, there was no significant interaction for using the guided questions neither on the performance outcomes nor the attitude. The students who worked individually with the guided questions achieved the highest project outcome mean and showed significant mean differences from the other three conditions. However, there were no significant mean differences for those who worked in groups with the guided questions.

One of the possible explanations of this study result might be related to the extensiveness of using the guided questions. The interview results indicated that not all students used the guided questions although they were supposed to use them to plan, develop, monitor, and evaluate their projects. Therefore, the students in the IQ condition might have used the guided questions more effectively than those in the GQ group. According to the document postings, most students in the IQ condition planned their project based on their answers to the guided questions. On the other hand, the students in the GQ group posted fewer postings, and the contents of the postings revealed that the students did not use the guided questions much.

As far as the students' attitude towards the problem solving, it seemed there was a ceiling effect. Since there was no statistically significant effect it was hard to examine whether different conditions influenced their problem solving attitude or not. However, most students from the four conditions answered that they liked working on the project and liked the problem-solving materials, which showed through the high mean scores from the IMMS and the problem-solving attitude questionnaire.

3. Does the use of the collaborative groups have effects on problem solving in WBI on attitude toward problem solving and academic performance?

The result of ANOVA indicated that there was a significant interaction of collaborative groups on students' performance. The students who worked in collaborative groups without the guided questions (GC) performed better than those who worked individually without the guided questions (IC).

The findings supported previous research (Lin, 2001; Webb & Palincsar, 1996; Zhang & Harkness, 2002) on the advantage of group interactions in supporting students' cognitive and metacognitive development. Greene and Land (2000) found that group interactions were useful in influencing the development of ideas only when group members offered suggestions, when they were open to negotiation of ideas, and when they shared prior experience. The qualitative data revealed that the GC group actively engaged in the group discussion throughout the problem-solving processes for the project. The effective collaboration seemed to help them to achieve better outcomes than those who worked individually.

There was no statistical significance on problem-solving attitude as it was mentioned earlier. Whether the students engaged in the collaborative groups or not, students liked the project because they had an opportunity to apply all skills and knowledge learned in the semester to the final project. Many students also stated that they liked the project because it used a realistic scenario and helped them to transfer to their professional life in the near future.

4. How does the use of the guided questions influence students' process of developing a solution to a problem-based learning scenario in a web-enhanced learning environment?

The analysis of the discussion board postings showed that students who used guided questions posted initial messages that were more detailed and organized than those who did not use the guided questions. Students in the IQ condition, posted messages related to planning and evaluating their own projects more than any other condition group. On the other hand, students who did not use the guided questions showed from their postings that they planned the final projects based on the grading criteria and minimum requirements rather than problem solving processes suggested by the guided questions. Therefore, the messages did not include many thoughts about how the final project would be presented as a whole.

The qualitative results suggested that guided questions served as cues to direct students' attention to important and relevant information that the students might not have considered. The finding is consistent with previous research (e.g., Ge & Land 2003; Osman & Hannafin, 1994). The guided questions seemed to help students to represent the problem, plan the solution development by asking what kind of information they have to gather to develop a solution. In that perspective, the guided questions facilitated students' cognitive thinking. In addition, answering the guided questions made students aware to monitor their own understanding and the solution outcome. Therefore, the guided questions seemed to facilitate metacognitive thinking.

Along with using the guided questions, using the online discussion board might have positively influence students' cognitive and metacognitive processes. According to Chi and Glaser (1985), self-explanation facilitated problem-solving processes. The qualitative study results indicated that writing down thoughts and plans helped students to develop the solution.

According to the case study by Lin (2001), questions can prompt students to make arguments for their solutions and decisions, and thus make thinking explicit. The qualitative data also showed that the guided questions served as guidelines to facilitate students' problem solving. For example, some students mentioned that answering the guided questions assisted them in organizing the outline for the project

5. How does the use of the collaborative groups influence students' process of developing a solution to a problem-based learning scenario in a web-enhanced learning environment?

The study results showed a variety of group dynamics. At first, the GQ students had good interaction among group members and collaborated well in the first class session when they planned the project. On the other hand, the classroom observation revealed that the GC students did not show much enthusiasm toward group collaboration in the classroom. However, toward the end of the project, there was lack of collaboration in the GQ condition and this treatment group performed poorer than the GC condition.

The findings might be explained with social loafing. Social loafing is the performance inhibiting effect of working in a group that involves relaxing individual effort based on the belief that others will take up the slack (K. D. Williams & Karau, 1991). When there was no social loafing, this dissertation study found that the collaborative group was effective on complex problem-solving since the GC condition performed better than the IC condition. Overall, the students in GC condition regularly participated in online group discussion and that allowed them to evaluate each other's work before they submit the final project. This study result confirmed the previous research on collaborative learning on complex problem-solving (Blumenfeld et al., 1996; Carr, 2001; Ge & Land, 2003). According to Bereiter and Scardamalia (1989), the key to the strategy of peer interactions is social construction of knowledge mediated through interpretation, elaboration, explanation, negotiation, and argumentation. Therefore, if students were not actively engaged in discussion activities such as questioning, explaining, elaborating, and constructing arguments, they may not be able to benefit much from the collaboration process.

The different group dynamics between the GQ and GC condition might be explained with social compensation effect as well. Social compensation is the tendency to work harder in a group to make up for the weaknesses of others in the group when the task is important and motivation to perform is high (Aronson, Wilson, & Rakert, 2004). According to the quantitative data results, the GC condition has slightly higher score on the IMMS and problem-solving attitude surveys than the GQ group. The higher motivation and commitment to the project in the GC group seemed to help them to achieve better outcomes in general.

Limitations of the Study

The followings are some limitations of this study observed by the researcher.

1. This study was specifically designed to test the effect of the guided questions and the collaborative groups at a college of education, where the majority of students are female and Caucasian. Therefore, the population for this study may not be representative of other institutions of higher education that have different populations from students in this study. However, the study findings indicated that there was no

significant difference among different genders and ethnicities on problem-solving processes, outcomes, and attitudes.

2. This study was conducted in a hybrid setting where students met face-to-face and online. In this course, the role of the instructor was that of facilitator or coach rather than lecturer. Therefore, instructors did not provide solutions to students. However, students might have had more chances to ask questions of instructors than those who were in WBI. Although students were advised to collaborate via the course website only, there was a limitation representing this population of other students in different types of web-based learning environments where courses are delivered fully online. Therefore, this study used the term, *web-enhanced,* instead of using *web-based* learning environment.
3. There were limited observations of group interactions. There were classroom observations to identify whether students collaboratively worked on their projects. Students were strongly encouraged to communicate on the online discussion board for their collaboration outside of the classroom. However, some groups met face-to-face after the class session or communicated via emails. Therefore, there were limitations to capture all group interactions inside and outside of the classroom. However, the number, length, and the contents of the discussion postings showed that the online discussion board was one of the major means used to communicate among group members. In addition, the eight semi-structured interviews provided additional information and insights that were not able to be captured by observations and discussion postings.
4. Depending on individuals, the use of the guided questions varied. The instructor strongly encouraged students to use the guided questions when the students started the

project. The instructor showed the questions on the data projection screen and briefly went over the importance and the purpose of using them. However, qualitative data discovered that not everyone used the guided questions to plan and monitor their problem-solving processes.

5. The scoring rubric used in this study did not exactly match with the guided questions. While the scoring rubric for the project emphasized what the project outcomes should be, the guided questions were focused on planning the project. However, the purpose of providing the guided questions was to facilitate students' problem solving, especially for planning processes. The scoring rubric reflected what the students were expected to develop as the result of the complex problem solving task.

Implications of the Study

Using the collaborative group, as the study findings provided, showed the positive affects on problem-solving processes and outcomes. For example, the discussion board message analysis revealed that the students in the GC group asked questions, provided explanations and feedback. As a result, they revised their draft as required and created high-quality outcomes. However, GQ students did not post any message that evaluated their solutions.

Working in a group itself did not guarantee the collaboration, which requires students to actively engage in tasks to accomplish a common mission. The GC students picked up the collaboration process well and had benefits from their well-organized group work. On the other hand, the GQ students struggled to work collaboratively, and their group project outcomes showed lack of consistency and unity.

To enhance the effect of the collaboration, training will be needed to prepare students how to moderate their group discussion and problem-solving since not all students are familiar with the collaboration. Instead of the training, a list of guidelines for group problem-solving could help students monitor their own group collaboration. Some students showed good moderation skills on the online discussion boards as this study proceeded. Depending on the students' level of group interaction experience and their collaboration abilities, instructor's moderation will be beneficial as well. According to Zhang's study (2003), when instructors moderated the group problem-solving processes, students were able to model the problem-solving process easily.

This study suggested that the guided questions were effective when students individually solved complex problems. However, the guided questions did not positively influence students' outcomes when they worked in the collaborative groups. These findings can be explained by different amounts of time investment on different aspects of learning. For example, individuals spent more time on exploring details of the project requirements, whereas groups spent more time engaged in metacognitive activities during the group discussion. The guided questions served as a guideline for the problem-solving process and students who worked individually spent more time on answering the questions and outlined their solutions. On the other hand, students in the collaborative groups seemed to rely more on group communication than using the guided questions to plan their projects.

In addition, the survey results showed that the students in the collaborative group conditions wanted more time working on the projects than those who worked individually. In general, group problem-solving processes took longer time than individual ones, and this factor might hinder students from spending more time on using the guided questions.

Therefore, a brief training of an effective collaboration or instructor's moderation should be implemented to provide assistance for group problem-solving.

Implications for Future Research

This study suggested that the working in the collaborative groups is more effective than working alone when the students were engaged in complex problem-solving. However, this study was not able to answer specifically why students in the GQ condition performed poorer than those who were in GC conditions. For a better understanding of group dynamics, researchers should look at a variety of aspects of online collaborative learning such as difficulty of the task, the media, and facilitation strategies. The research should examine the group dynamics from group creation to monitoring of the solutions. To investigate the collaboration process, a closer look into all communication protocols among group members will be required. To answer how students collaborate and what factors influence their effective collaboration, a descriptive analysis and a discourse analysis of the online discussion will be necessary.

Based on the results of this study, the guided questions supported students to have better problem-solving outcomes when the students worked individually. On the other hand, the guided questions were not as effective when students worked in the collaborative groups. These findings raise the question of what level of scaffolding is too much. The future research should examine the relationship between the level of difficulty and complexity of the problem and the level of supports for students' problem-solving process. For example, when the task is very complex and difficult, will students require more supports? When the students solve easier problems, will those supports be additional tasks that may interfere with their performance? Regarding the task complexity, the future research can look at the correlation between the difficulty and complexity of the tasks and the group dynamics. Future research question should explain: How the group dynamics change as the students are engaged in more difficult tasks? What kind of instructional strategies should be implemented to support students' problem-solving? To what degree would students rely on those instructional supports?

As this study was primarily interested in outcomes of the groups as a whole, the outcomes of each group member were not measured. However, the group performance might vary depending on a couple of advanced students in a group. For future research, studies looking at both group and individual outcomes may be able to better understand the group dynamics and collaboration for problem-solving.

To understand the relationship between the communication protocols and the collaboration pattern, use of different communication modes for online collaboration will be needed. For this study, the asynchronous discussion board was used to communicate among group members. However, the students are familiar with synchronous online communication by using instant messengers in their daily lives. In addition, there are many advanced ways to communicate online these days and those methods have not been used in educational settings as much as in everyday life. Therefore, research using more advanced and different communication methods to identify effective ways to collaborate online will be worthwhile to conduct.

The instructional task used in this study was complex and it required technical skills as well as problem solving skills. Therefore, the instructional task used in this study might not have been the best material to investigate students' problem solving processes and outcomes since some students might have great critical thinking skills but not very good technical skills that are required to complete the task. Therefore, in future research, researchers should use instructional material that requires more decision making and critical thinking to solve a problem such as case analysis and diagnosis.

Concluding Remarks

This study has provided valuable insight into complex problem solving outcomes, attitudes, and processes in a web-enhanced environment. It also suggested instructional methodologies for complex problem solving using PBL, the collaborative groups, and guided questions. Findings from this study will inform future research efforts on collaborative learning and complex problem solving in web-enhanced educational environments

APPENDIX A: TASK MATERIAL FOR COLLABORATIVE GROUPS

Final Project

Purpose

The purpose of this assignment is to incorporate all of the skills that you have learned this semester in a project that could be practical in a real classroom environment. .

Directions

The class will divide into groups (4 - 5 people per group), and each group will create a project in response to the following scenario:

> Assume that you are a teacher at a Florida public school. (Choose a specific school level and department. It would be nice if you chose a specific school.) Whenever you assigned students a research project, you would direct them to the library/media center to look up the information in reference books. Since several students usually wanted to use the same text, there was a lot of wasted time. It was difficult to keep students focused on information gathering. You want to develop solutions to this problem and develop a website that contains not only the helpful links, but also learning modules and activities that students can explore and learn.

Before you start creating the slides, spend time to plan this assignment. Discuss some ideas with your group members on the assigned group discussion board.

The scenario is intentionally not very detailed so that your group will have the chance to tailor the specifics to what you want to do. You have a lot of freedom to be creative with this project!

Also, this would be a great time to review your notes from the presentation on Problem-Based Learning. Your group needs to figure out what questions to ask, how to find the information you'll need to complete your task, and who's doing what by when.

The final product for each of these projects should be a unified set of materials that were developed in accordance with the stated goals of the project. The whole project as a unit should be greater than the sum of the parts. It will require close communication and cooperation among all members of your group

Each project should include:
MS Word (at least two different products other than web pages)
PowerPoint (at least 10 slides)
HyperStudio (at least 10 cards)
Inspiration product (at least 15 nodes)
An Excel product
Web site (one main page and at least three additional pages). All materials in this project should be linked to the web site.
Demonstrate your ability to save your products at html and link them to your site. (at least once)
Demonstrate your ability to link non-html files to your site. (at least twice)
Zip your final product and submit it in the BlackBoard folder below.
Each group member must submit a product.

You must use the Discussion Board for intragroup communication and collaboration. Please post materials and show evidence of group reflection and decision making on the Discussion Board. Feel free to visit other groups discussions. See what they are doing. Comment on their materials. 6 points of your grade will be based on your demonstrated used of the Discussion Board in the development of your product.

Getting Started

Organize yourselves as a group. Assign tasks. Set up a communication system. Use everything you have learned this semester.

EVERYTHING THAT YOU CREATE FOR THIS PROJECT MUST BE NEW AND ORIGINAL. You may not reuse anything that you have done before or revise anything that you have done before, either in this class or for any other purpose.

Evaluation Criteria

The Final Project will be worth 22 points.
The Final Project will be graded on the quality of product based on the following criteria.
The grade for the final product will be in two parts:

- 14 points for the product submission. Each person in the group will receive the same grade for the product.
- 8 points for group participation as evidenced by postings in the Discussion. Each person in the group will receive a separate grade based on their level of participation. At the end of the

project period, each student will submit an evaluation statement of each group members contributions.

You will receive only one grade for the project. There will be no re submissions.
It is important that you submit your very best project.

Grading Criteria:

- accomplishing the goals of the project that you selected
- overall development of your product
- cohesiveness of your product
- good organization, aesthetics, appropriateness of images and text, use of color, etc.
- content: links and information that are appropriate for the goals of your project
- overall clarity
- evidence group collaboration including the use of the Discussion Board for group communication.

The web sites should have:

- A home page (index.html)
- At least three additional pages with links to each other with proper filename (name.html).
- Colored backgrounds or images as backgrounds.
- At least 1 images on every page.
- At least 3 links to other related web site (outside links).
- Good internal navigation throughout
- Links to all other products that you created for your project

The HyperStudio component should have:

- Effective stack design
- Satisfactory overall look-and-feel, using appropriate images, color, and fonts
- Logical navigation between cards with a quit button and restart button
- A colored or image background on each card.
- Proper use of images and other multimedia
- At least one animation
- Title card and an end card.
- Graphics and sound.

Your MS Word components should have:

- Presentation of an appropriate product with effective organization
- Creates satisfactory overall look-and-feel, using appropriate images, color, and fonts
- Includes coherent content with correct spelling and grammar

Your PowerPoint component should have:

- A product presented with appropriate quantity and use of graphics,
- Effective organization, limit text
- Includes appropriate transitions, animations, graphics, color, fonts
- Present information in an interesting and entertaining way
- Incorporate graphics to enhance your message. Use at least one on each slide.
- Use appropriate graphics that will not detract from it.
- Pictures must be clear. Use Photoshop for modifying your pictures if necessary
- Use readable colors and fonts. Your presentation must be attractive.
- Use Word Art and Clip Art
- Use appropriate slide transition effects
- Use animation on at least three different slides
- Use at least one advanced feature, and
- Check for typographical errors.

Your Inspiration component should:

- Include all required components. (at least 15 nodes)
- Import at least one graphic from an outside source.
- Uses all the functions of Inspiration that you learned in class.
- Be logical and represent the "flow" of the intended project.
- Be appropriate to the project selected.

APPENDIX B: TASK MATERIAL FOR STUDENTS WHO WORK INDIVIDUALLY

Final Project

Purpose

The purpose of this assignment is to incorporate all of the skills that you have learned this semester in a project that could be practical in a real classroom environment. .

Directions

Each individual will create a project in response to the following scenario:

> Assume that you are a teacher at a Florida public school. (Choose a specific school level and department. It would be nice if you chose a specific school.) Whenever you assigned students a research project, you would direct them to the library/media center to look up the information in reference books. Since several students usually wanted to use the same text, there was a lot of wasted time. It was difficult to keep students focused on information gathering. You want to develop solutions to this problem and develop a website that contains not only the helpful links, but also learning modules and activities that students can explore and learn.

The scenario is intentionally not very detailed so that you will have the chance to tailor the specifics to what you want to do. You have a lot of freedom to be creative with this project!

Also, this would be a great time to review your notes from the presentation on Problem-Based Learning. You need to figure out what questions to ask and how to find the information you'll need to complete your task.

The final product for each of these projects should be a unified set of materials that were developed in accordance with the stated goals of the project. The whole project as a unit should be greater than the sum of the parts.

Each project should include:
MS Word (at least two different products other than web pages)
PowerPoint (at least 10 slides)

HyperStudio (at least 10 cards)
Inspiration product (at least 15 nodes)
An Excel product
Web site (one main page and at least three additional pages). All materials in this project should be linked to the web site.
Demonstrate your ability to save your products at html and link them to your site. (at least once)
Demonstrate your ability to link non-html files to your site. (at least twice)
Zip your final product and submit it in the BlackBoard folder below.
Each individual must submit a product.

You must use the Documentation Board for reporting your progress of the final project. Please post materials and show evidence of your reflection and decision making on the Documentation Board. 6 points of your grade will be based on your demonstrated used of the Documentation Board in the development of your product.

Getting Started

You may not reuse anything that you have done before. You, however, may revise anything that you have done before.

Evaluation Criteria

The Final Project will be worth 22 points.
The Final Project will be graded on the quality of product based on the following criteria.
The grade for the final product will be in two parts:

- 15 points for the product submission.
- 7 points for participation as evidenced by postings in the Documentation board.
- You will receive only one grade for the project. There will be no re submissions.
  It is important that you submit your very best project.

Grading Criteria:

  - accomplishing the goals of the project that you selected
  - overall development of your product
  - cohesiveness of your product
  - good organization, aesthetics, appropriateness of images and text, use of color, etc.
  - content: links and information that are appropriate for the goals of your project

- overall clarity
- evidence of problem-solving process including the use of the Documentation Board.

The web sites should have:

- A home page (index.html)
- At least three additional pages with links to each other with proper filename (name.html).
- Colored backgrounds or images as backgrounds.
- At least 1 images on every page.
- At least 3 links to other related web site (outside links).
- Good internal navigation throughout
- Links to all other products that you created for your project

The HyperStudio component should have:

- Effective stack design
- Satisfactory overall look-and-feel, using appropriate images, color, and fonts
- Logical navigation between cards with a quit button and restart button
- A colored or image background on each card.
- Proper use of images and other multimedia
- At least one animation
- Title card and an end card.
- Graphics and sound.

Your MS Word components should have:

- Presentation of an appropriate product with effective organization
- Creates satisfactory overall look-and-feel, using appropriate images, color, and fonts
- Includes coherent content with correct spelling and grammar

Your PowerPoint component should have:

- A product presented with appropriate quantity and use of graphics,
- Effective organization, limit text
- Includes appropriate transitions, animations, graphics, color, fonts
- Present information in an interesting and entertaining way
- Incorporate graphics to enhance your message. Use at least one on each slide.
- Use appropriate graphics that will not detract from it.

- Pictures must be clear. Use Photoshop for modifying your pictures if necessary
- Use readable colors and fonts. Your presentation must be attractive.
- Use Word Art and Clip Art
- Use appropriate slide transition effects
- Use animation on at least three different slides
- Use at least one advanced feature, and
- Check for typographical errors.

Your Inspiration component should:

- Include all required components. (at least 15 nodes)
- Import at least one graphic from an outside source.
- Uses all the functions of Inspiration that you learned in class.
- Be logical and represent the "flow" of the intended project.
- Be appropriate to the project selected.

APPENDIX C: PRE-INTERVENTION ASSESSMENT

I. Background Information

1. Name ________________________________
2. What year are you in?

a. Freshmen	b. Sophomore
c. Junior	c. Senior

3. What is your gender?

Male	Female

4. What is your age? ___________
5. What is your major?_________________________________

II. Computer Experience

Scale

1 = Never used it

2 = Beginner: used a couple of times

3 = Intermediate: Able to create a product with this software but do not know advanced features

4 = Advanced: Able to use sophisticated features of this software

5 = Expert: Able to teach this software

How would you describe your present familiarity with :

6. MS Word?	1	2	3	4	5
7. MS PowerPoint?	1	2	3	4	5
8. MS Excel?	1	2	3	4	5
9. Hyperstudio?	1	2	3	4	5
10. Inspiration?	1	2	3	4	5

APPENDIX D: GUIDED QUESTIONS

Things to consider before generating a solution

I. How do I define the problem?

   a. What are the problems and situations?

   b. What information do I need for this problem?

      - What grade level of students did I select?
      - What information do I expect the students to learn?
      - What level of prior knowledge do I expect the students to have?

II. What kind of final product do I need to generate?

   a. What should the final product do to the students?

   b. What kind of contents do I need to generate the final product?

   c. What are the barriers and constraints to in developing the final products?

III. What are the reasons/arguments for my proposed product?

   a. How would I justify this specific content design?

   b. How would I justify the use of this software for the product?

   c. Do I have evidence to support my product?

IV. Am I on the right track?

   a. Have I discussed both the technical components and the issues with usage (eg. usability and effectiveness)?

   b. Are there alternative solutions?

APPENDIX E: POST-INTERVENTION ASSESSMENT

Problem-Solving Process Survey

Guided questions and Collaborative Treatment Group

Participant Survey

The purpose of this survey is to gather your perceptions about the problem based learning activity you just completed. Your honest feedback will be appreciated and used to determine areas for improvement.

Please rate statements below using the following rating scale.

1 = Strongly disagree 2 = Disagree 3 = Neutral 4 = Agree 5 = Strongly agree

1. I enjoyed working with other people on the activity.	1	2	3	4	5
2. The activity was easier to do because I worked with other people.	1	2	3	4	5
3. Working with others helped me do better on the activity	1	2	3	4	5
4. I liked communicating with my team using the computer.	1	2	3	4	5
5. Collaborating with my team, using the computer, was easy to do.	1	2	3	4	5
6. Guided question made me think hard on the activity	1	2	3	4	5
7. The guided question prepared me well to solve the problem scenarios.	1	2	3	4	5

8. My team and I used the guided questions to discuss how to solve the assigned scenarios.	1	2	3	4	5
9. My team and I had enough time to solve the problem scenarios. (related to methods)	1	2	3	4	5
10. The scenarios in this program were realistic and applicable to a future school teacher.	1	2	3	4	5
11. I feel better prepared to solve similar problems after doing this activity	1	2	3	4	5
12. The problem solving skills I learned in this program will help me in my teaching career.	1	2	3	4	5

13. When solving complex problems, I prefer to work:

a. By myself

b. With one partner

c. With two partners,

d. With more than two partners

14. Please write down the general steps that you followed to solve the assigned problem scenarios.

15. What did you like best about this problem solving activity?

16. What would you do to make this activity better?

Post-intervention Assessment – Problem-solving process Survey

No Guided questions and Collaborative Groups Treatment Group

Participant Survey

The purpose of this survey is to gather your perceptions about the problem based learning activity you just completed. Your honest feedback will be appreciated and used to determine areas for improvement.

Please rate statements below using the following rating scale. Name____________________

1 = Strongly disagree 2 = Disagree 3 = Neutral 4 = Agree 5 = Strongly agree

1. I enjoyed working with other people on the activity.	1	2	3	4	5
2. The activity was easier to do because I worked with other people.	1	2	3	4	5
3. Working with others helped me do better on the activity	1	2	3	4	5
4. I liked communicating with my team using the computer.	1	2	3	4	5
5. Collaborating with my team using the computer was easy to do.	1	2	3	4	5
6. My team and I had enough time to solve the problem scenarios. (related to methods)	1	2	3	4	5
7. The scenarios in this program were realistic and applicable to a future school teacher.	1	2	3	4	5
8. I feel better prepared to solve similar problems after doing this activity	1	2	3	4	5
9. The problem solving skills I learned in this program will help me in my teaching career.	1	2	3	4	5

10. **When solving complex problems, I prefer to work**:

a. By myself

b. With one partner

c. With two partners

d. With more than two partners

11. **Please write down the general steps that you followed to solve the assigned problem scenarios.**

12. **What did you like best about this problem solving activity?**

13. **What would you do to make this activity better?**

Post-intervention Assessment – Problem-solving process Survey

Guided questions and Individual Treatment Group

The purpose of this survey is to gather your perceptions about the problem based learning activity you just completed. Your honest feedback will be appreciated and used to determine areas for improvement.

Please rate statements below using the following rating scale.

1 = Strongly disagree 2 = Disagree 3 = Neutral 4 = Agree 5 = Strongly agree

1. Guided question made me think hard on the activity	1	2	3	4	5
2. The guided question prepared me well to solve the problem scenarios.	1	2	3	4	5
3. The scenarios in this program were realistic and applicable to a future school teacher.	1	2	3	4	5
4. I feel better prepared to solve similar problems after doing this activity	1	2	3	4	5
5. The problem solving skills I learned in this program will help me in my teaching career.	1	2	3	4	5

6. **When solving complex problems, I prefer to work**:

a. By myself

b. With one partner

c. With two partners

d. With more than two partners

7. **Please write down the general steps that you followed to solve the assigned problem scenarios.**

8. **What did you like best about this problem solving activity?**

9. **What would you do to make this activity better?**

Post-intervention Assessment – Problem-solving process Survey

No Guided Questions and Individual Treatment Group

The purpose of this survey is to gather your perceptions about the problem based learning activity you just completed. Your honest feedback will be appreciated and used to determine areas for improvement.

Please rate statements below using the following rating scale.

1 = Strongly disagree 2 = Disagree 3 = Neutral 4 = Agree 5 = Strongly agree

1. The scenarios in this program were realistic and applicable to a future school teacher.	1	2	3	4	5
2. I feel better prepared to solve similar problems after doing this activity	1	2	3	4	5
3. The problem solving skills I learned in this program will help me in my teaching career.	1	2	3	4	5

4. **When solving complex problems, I prefer to work**:

a. By myself

b. With one partner

c. With two partners

d. With more than two partners

5. **Please write down the general steps that you followed to solve the assigned problem scenarios.**

6. **What did you like best about this problem solving activity?**

9. **What would you do to make this activity better?**

APPENDIX F: POST-INTERVENTION ASSESSMENT

Short Version of the Instructional Material Motivation Survey

Please rate statements below using the following rating scale.

1 = Not true2 = Slightly true 3 = Moderately true 4 = Mostly true 5 = Very true

Instructions: We are trying to find out how to design better learning modules Your answers will help us to do this. Please read the following questions and choose the answer that best tells how you really felt about the final project. The answers that you give will not affect your grade

Be sure to fill In your name and social security number on the answer sheet Blacken the bubbles on the answer sheet for your answer Below Is the key to the answers.

ANSWER KEY:	**1 (or A)=NOT TRUE**
	2(or B)=SLIGHTLY TRUE
	3 (or C) = MODERATELY TRUE
	4 (or D) = MOSTLY TRUE
	5 (or E) = VERY TRUE

	Instructional Material Motivation Survey	Not true ← → Very True				
1	The way that the information for the final project was introduced got my attention.	1	2	3	4	5
2	The final project made me curious.	1	2	3	4	5
3	The style of writing in the materials in the final project is boring.	1	2	3	4	5
4	Finishing the final project successfully was important to me.	1	2	3	4	5
5	I can see how the content of the final project is related to things I already know about.	1	2	3	4	5
6	The knowledge in the final project is Not useful to me.	1	2	3	4	5
7	The way the information was organized made me feel that I could be successful in the final project.	1	2	3	4	5

8	I could understand most of the content of the final project.	1	2	3	4	5
9	After I worked on the final project for a while, I felt confident about what I was doing.	1	2	3	4	5
10	I was happy about finishing the final project successfully.	1	2	3	4	5
11	I did NOT think the final project was well designed.	1	2	3	4	5
12	I liked working on the final project.	1	2	3	4	5

APPENDIX G: PERFORMANCE SCORING RUBRIC

Student Name:		**Score:**	
This analytic rubric is used to evaluate specific tasks performed when creating worksheets for an assigned scenario. If the task has been completed, all points are awarded. No points are awarded if the task is not complete.			
Category	**Scoring Criteria**	**Points**	**Teacher Evaluation**
Requirements	Does the project include all the required elements?	**10**	
Functionality	Is required functionality available? Are all hyperlinks working? Is the folder compressed/zipped correctly?	**10**	
Visual Clarity	Are the purposes of visual elements clear to users? Do all icons, buttons, and graphics make sense to the user? Is it difficult to figure out what the visual elements mean? Did the layout of the screen cause confusion for the user?	**10**	
Content	Is the language at the correct reading level for the intended audience? Does the project include enough information to guide target audience?	**10**	
Navigation	Is it easy to understand how to navigate the webpages?	**10**	
Score	**Total Points**	**50**	
Deadline	All "turn-in" assignments are expected to be completed by the assigned deadline. No credit will be given after this time.		

APPENDIX H: SEMI-STRUCTURED INTERVIEW QUESTIONS

1. Did your group work collaboratively?
2. Did you use the guided questions for planning the project?
3. What part of collaboration was successful?
4. How would you do differently to maximize the collaboration effect?
5. Do you think the guided question helped you? Why or why not?
6. How do you like the problem scenario?
7. How do you like the problem-based learning approach for the final project?
8. What kind of support would be helpful for their problem solving process and outcome?
9. What types of support was the most helpful?
    A. detailed criteria
    B. problem description
    C. guided questions
    D. collaboration among group members
    E. guidance from the instructor

APPENDIX I: DISCUSSION BOARD MESSAGE CODING STRUCTURE

Code	Description	Example
1. Defining a problem	Students define the problem of a problem solving task and generate goals and seek information required to solve the problem.	“We need to get started on this project. If we can decide on an overall school and grade level that would be great. /then we could brainstorm.”
2. Developing solutions	Students develop solution with explanation on how the solution works.	“Here is the grade book for Excel. If there is anything that needs to be changed, please let me know and I will do it by class session tomorrow.”
3. Providing justification/clarification	Students provide justification and clarification while they develop solutions.	“That is what the instructor said to do, so you are definitely on the right track about making hyperlinks on the website.”
4. Monitoring and evaluating problem solutions	Students evaluate the proposed solution and discuss constraints	“There was a huge space in the first paragraph between student and will.”
S. Substantial	Messages that contribute to the discussion and problem solving processes	“The group has decided to have a language art class. This class will have reading assignments and vocabulary words…”
U. Unsubstantial	Messages that simply agree or disagree without providing explanations or justifications	“It sounds good”

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BIOGRAPICAL SCHETCH

Sookyung Suh was born and raised in Seoul, Korea. She studied English at Seoul Foreign Language High School and continued studying modern languages at Hankuk University of Foreign Studies. She holds B.A. in English and Italian. Before she came to the United States, she worked as an English instructor, translator, and interpreter for private companies.

She received the University Fellowship from Florida State University for her M.S. in Instructional Systems. She had worked at Learning Systems Institute (LSI) at Florida State University as a research assistant for three and a half years. While she was working at LSI, she assisted the U.S. Navy and Army to design, develop, and evaluate performance support systems for military human performance consultants. She also taught Introduction to Educational Technology, an undergraduate course in College of Education, for two years. She worked with faculty in Instructional Systems and Psychology programs to revise their curriculum. She has been active in international and national conferences. She has presented over a dozen of papers at major conferences and published one journal article. She also won the PacifiCorp Design and Development competition at the annual Association for Educational Communication and Technology conference in 2005.

As the president of the Instructional Systems Student Association, she has been dedicated to promoting communication and teamwork among students, alumni, faculty and staff to enhance the academic and professional development of the IS community and increasing the program's visibility locally and globally.

One of her current research interests is to promote students' engagement, motivation, and performance for complex problem solving, especially in web-based learning environments. She is also interested in performance improvement at work places through systematic and systemic analysis, which she hopes to continue in her new job as a business management analyst at BearingPoint. She loves to teach and plans to be a professor and a lifelong learner. She can be reached at sookyung_suh@yahoo.com.