COLLABORATIVE PROBLEM-BASED LEARNING IN ONLINE ENVIRONMENTS

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ABSTRACT

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Collaborative problem-based learning (PBL) in online environments has become one of the important areas for research with the rapid growth of online learning and the need for innovation in instruction. Although current literature provides interesting and useful insights, it does not provide practical guidelines for designing and implementing collaborative PBL in online environments. Thus, this study sought to provide a first step in creating a more comprehensive and useful knowledge base to guide practitioners, such as instructors and instructional designers, who design online PBL courses or use the PBL approach in online courses.

Utilizing the formative research methodology, which is a kind of qualitative case study, and the grounded theory methodology with multiple case studies, this research examined three graduate-level online courses that utilize collaborative PBL: (1) "Technology: Use and Assessment," (2) "Introduction to Reference," and (3) "Advanced Problems in Librarianship: Collection Development." From each case, two kinds of data were collected: descriptive and evaluative. These data were collected from multiple sources, including interviews, observations, and document review. The data collection began at the start of the Fall 2005 semester and ended about two weeks after the end of the semester. Data analysis was intertwined with data

collection. Qualitative data from each case were analyzed using the constant comparative method.

Beyond describing what happened in each case, this study identified what worked and did not work well in the collaborative PBL and explored how the collaborative PBL could be improved. Based on cross-case analyses, this study proposed a series of guidelines for designing and implementing collaborative PBL in online environments. They provide practical tips for diverse stages of the design and implementation of online PBL. Researchers are encouraged to test the guidelines in diverse situations to revise and refine them and to develop more comprehensive and practical guidelines for online collaborative PBL.

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CHAPTER I.

INTRODUCTION

Background

We encounter and solve problems all the time. Problem solving is regarded as the most important activity in our everyday and professional lives (Jonassen, 2000). In today's information-age society, the importance of problem solving seems to have become greater than ever before (Reigeluth, 1999). More and more jobs are ill-defined, so organizations need people who are able to solve problems, especially ill-defined problems. The importance of problem-solving has been noted by many educators and researchers, and problem-based learning (PBL) has been used in a variety of disciplines and levels. Research supports that PBL promotes more in-depth understanding of content (Coles, 1985; Newble & Clarke, 1986; Vernon & Blake, 1993) as well as the retention and application of knowledge acquired (Berkson, 1993; Norman & Schmidt, 1992), fosters self-directed learning skills (H. Barrows & Tamblyn, 1980; Norman & Schmidt, 1992), and provides an enjoyable and stimulating learning environment for both students and teachers (Albanese & Mitchell, 1993).

Vygotsky (1978) stressed that learners can solve a problem that could not be solved alone under adult guidance or with peer collaboration. Research also suggests that collaborative learning has a positive effect on problem solving (Mergendoller *et al.*, 2000). 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). The combination of problem-solving and collaborative learning, that is, collaborative problem solving (CPS) is effective especially when the learning involves heuristic tasks and developing conceptual understandings and cognitive strategies (Nelson, 1999). Several studies

conducted to analyze the effect of collaboration on problem solving found that collaboration improved performance on complex or higher-order thinking activities (S. D. Johnson & Chung, 1999; Mergendoller et al., 2000). In these studies, learners appeared to benefit from the opportunity to discuss the problem, brainstorm potential solutions, and arrive at a final solution. In a meta-analysis of the use of collaborative learning in higher education courses, collaborative learning was found to promote higher achievement, higher level reasoning, more frequent generation of ideas and solutions, and greater transfer of learning than individual or competitive learning strategies (D. W. Johnson *et al.*, 1991).

Recently, online courses are rapidly increasing at universities as well as in corporate settings in the United States and abroad. More and more learners enroll in distance education programs, while the enrollments in residential programs are relatively decreasing. Since online learning enables working in convenient places with highly flexible schedule, it attracts adult learners who have jobs and other commitments. With online learning, one can update his or her knowledge and skills while still maintaining a full-time job. In addition to the convenience and accessibility, online learning has the potential for providing such a learning environment, which reflects the new paradigm of instruction (Reigeluth, 1999) that values learner-centered instruction, collaborative learning, and problem-based learning. Specifically, online learning environments enables students to take control of their learning (Vrasidas & McIsaac, 2000), engage students in higher level thinking through active and interactive learning (Harasim *et al.*, 1997), provides an easy access to rich and dynamic resources, expose learners to multiple perspectives (Harasim et al., 1997), provides authentic learning experiences (Kearsley, 1996), and promotes interactions and collaboration among the instructor and learners (Relan & Gillani, 1997).

Problem-based learning, collaborative learning, and online learning are all important areas in education. The combination of these three topics, that is, online collaborative PBL has become one of hot areas for research with the rapid growth of online learning and the need for innovation in instruction.

Statement of the Problem

Research has suggested that online learning environments require different instructional strategies from ones used in face-to-face settings. However, many online PBL courses appear to adopt PBL models developed for PBL in face-to-face settings and become simple duplications of face-to-face PBL courses. Most PBL models and guidelines available are for PBL in face-to-face environments, and they do not provide appropriate guidelines for online PBL. In addition, current literature on online PBL, which consists of many individual cases that focus on some part of PBL, such as tools or scaffolds used in problem-solving, does not provide the big picture of designing and implementing online PBL.

In order to design effective PBL experiences that are appropriate for online environments, and implementing them successfully, we need comprehensive guidelines that provide strategies for structuring and facilitating the whole problem solving process in an online environment. In addition, recognizing that every situation is unique in some ways, the guidelines need to also be situational. Therefore, the purpose of this study is to develop more comprehensive and practical guidelines for designing and implementing collaborative PBL in online environments.

Significance of the Study

The current literature consists of many individual cases of courses utilizing PBL in online environments. As mentioned already, many of these cases focus on some part of PBL. Thus there is not enough guidance for practitioners, such as instructional designers and instructors, who design online PBL courses or use PBL approach in online courses. We do not have clear ideas about how to structure collaborative PBL in an online environment and how to facilitate each activity or process in online PBL. This study seeks to provide a first step in creating more comprehensive and useful knowledge base to guide practitioners in a format that is easy for them to use.

CHAPTER II.

LITERATURE REVIEW

PBL

Origin

Problem-based learning was first developed at McMaster University medical school, Canada, in the late 1960s and has been widely adopted by many medical schools worldwide, including Maastricht University in the Netherlands, the University of Newcastle in Australia, the University of New Mexico, Harvard University, and South Illinois University (H. S. Barrows, 2000). From medicine, PBL has rapidly spread to other professional fields, including business, law, nursing, education, and engineering. Applications of PBL vary, being used on many levels – courses, programs, curricula, and institutions. University of Delaware and Samford University in the United States, Roskilde University and Maastricht University in Europe, and Monash University in Australia, for example, adopted PBL on the institutional level, while Ohio University adopted PBL on the program level in management education (Coombs & Elden, 2004).

What is PBL?

Definitions of PBL vary. Some people seem to believe that any kind of problem-centered approach could be PBL. In this case, PBL can include a broad range of instructional approaches, including project-based learning, case-based learning, and so forth. However, this study will view PBL as a unique approach differentiated from other similar approaches. In order to make the definition of PBL clear, I will address four main characteristics of PBL.

First, PBL is an instructional method that uses authentic, complex, ill-structured problems as the impetus for learning (Savery & Duffy, 1995). In other words, all learning activities are

anchored to a real-world problem or task that students will be likely to face in their careers (CTGV, 1992; Honebein *et al.*, 1993). Learning is situated in real-world contexts, and it can increase learner motivation (H. Barrows & Tamblyn, 1980; Berkson, 1993) as well as fostering retention and application of knowledge acquired (Berkson, 1993; Norman & Schmidt, 1992). The following definition of PBL shows that a problem is the centerpiece of the PBL:

> Problem based learning is an instructional strategy that uses a problem as a starting point for learning. The problem is one that students are apt to face as future professionals. The knowledge students are expected to gain during their training is organized around problems rather than the disciplines. Students work in project teams on these problems and assume a major responsibility for their own instruction and learning. (Bridges, 1992, p. 17)

The problem in PBL is designed to be ill-structured. Therefore, students are given insufficient information, and they identify what they need to learn in order to solve the problem and search for needed information. In this sense, PBL is most appropriate when the learning involves complex and ill-structured tasks, such as heuristic tasks, and developing conceptual understandings and cognitive strategies (Nelson, 1999).

Second, PBL is a learner-centered method that scaffolds learners to take a progressively increasing responsibility for their own learning (Coombs & Elden, 2004). In this respect, PBL is consistent with the constructivist perspective that stresses the importance of learners taking an active role in learning. Based on the work of many psychologists and educational philosophers, such as Dewey (1916), Piaget (1973), Vygotsky (1978), and Bruner (1996), constructivists assert that learners can learn actively and construct new knowledge based on their prior knowledge.

From this perspective, PBL promotes self-directed learning, and the PBL instructor plays the role of a facilitator.

Third, PBL focuses on helping learners acquire problem solving, reasoning, and metacognitive skills as well as domain-specific knowledge (H. S. Barrows, 1986). Students are encouraged to reflect upon the problem-solving process, and the instructor assumes a major role in probing and challenging learners' thinking and modeling the metacognitive thinking associated with the problem solving process. In this sense, PBL approach is cognitive apprenticeship and is well represented with the notions of scaffolding and zone of proximal development (ZPD) (Savery & Duffy, 1995).

Fourth, PBL involves social negotiation through group collaboration (Savery & Duffy, 1995). Knowledge is socially negotiated through collaborative learning. Learners working in small groups are encouraged to test their own ideas, perceptions, and beliefs against alternative views, examine the understanding of others, and thus expand their understanding of the issue of interest.

In sum, PBL is a learner-centered instructional approach that aims to help learners acquire both domain-specific knowledge and domain-independent knowledge, such as problem-solving, metacognitive, reasoning, critical thinking, self-directed learning, communication and teamwork skills, by using a problem as the starting point of, and stimulus for, learning in a collaborative learning environment.

How is PBL different from other inquiry-based methods?

How is PBL different from other inquiry-based methods, such as project-based learning and case-based learning? The line between problem- and project-based learning is often blurred, and the two terms are frequently used as synonyms. In fact, they are very similar in that both

take a learner-centered approach and use authentic, real-world tasks. However, project-based learning is different from problem-based learning in that it focuses more on end products (Esch, 2000). According to Blumenfeld et al. (1991), projects have two essential components: a driving question or problem and activities that result in a series of artifacts or products. The artifacts or products developed in project-based learning drives and shape the learning process. On the other hand, problem-based learning focuses more on inquiry rather than the end product. Therefore, there may or may not be an end product in problem-based learning, and the end product developed in problem-based learning could be simple and summative like a group report (Esch, 2000). According to Reigeluth, problem-based learning generally focuses on "decision making" to solve a problem, having a decision as a goal, while project-based learning focuses on "product making" having the product as a goal (personal communication, July 7, 2005).

According to Albanese and Mitchell (1993), PBL is differentiated from other methods in that in PBL the problem is presented first before students receive any instruction. Savery and Duffy (1995) argue that most case-based learning (CBL) approaches use cases as a means for testing one's understanding or as an example. They point out that the case in CBL approach is presented after the learning content is covered in order to help test understanding and support synthesis, while all of the learning in PBL arises out of the problem and anchored to the problem. In other words, PBL is different other problem-centered methods or inquiry methods in that it provides greater focus on inquiry and developing the metacognitive skills associated with problem solving (H. S. Barrows, 1986).

PBL models

When it comes to the process of PBL, the model developed by Howard Barrows for use in medical school setting is conceived as the most institutionalized or general form. The Barrows model can be described as follows (Boud & Feletti, 1997):

- Students, divided into small groups and assigned a facilitator, are presented with a problem.
- Students in small groups attempt to define the broad nature of the problem, generating ideas about possible solutions, based on their prior knowledge and experiences.
- Throughout the discussion, students define what they know and what they need to know by identifying learning issues.
- Students rank the learning issues generated in order of importance and formulate an action plan to solve the problem.
- Students engage in self-directed learning (SDL) and search for relevant information or resources. Faculty are available for consultation. Just-in-time (JIT) learning takes place in this stage since students search for information when the need to know is greatest.
- When students reconvene, they integrate their new knowledge and reexamine the problem based on their newly acquired knowledge. This cycle may repeat until new learning issues no longer arise.
- Once students feel that the problem has been successfully solved, they attempt to form generalization by discussing the problem in relation to similar and dissimilar problems.
- Students reflect on the problem-solving process and undergo self and peer evaluation.

As this model has been adopted by a variety of disciplines, it appears that there is a need for adapting the model according to specific learning situations. Duch (2001) noted that the

model that works in a medical school setting where students with high level of intellectual maturity and motivation work in small groups with a dedicated faculty facilitator, may not transfer well into different conditions such as a typical undergraduate setting with larger classes. Accordingly, there have been efforts to adapt the original PBL model to diverse situations. At the University of Delaware, well-known as the leader in the development of PBL in undergraduate education, for example, faculty members developed their problem-based courses based on their own decisions on the best way to use PBL for their students, shared with one another what was working and was not working in their course, and brainstormed ideas for overcoming the problems they encountered in adopting PBL in their typical undergraduate classes.

Several models of PBL, including floating facilitator model, peer tutor model, and large class model, were identified from those discussions, and have been used by many instructors in a variety of undergraduate institutions (Duch, 2001). In the floating facilitator model, students are divided into small groups of four, at most five, students and the instructor moves from group to group as the "floating facilitator" asking questions and probing students' thinking. In the peer tutor model, experienced peer tutors play a role of "floating facilitator" for two or three groups of six to eight students in large classes where there are not enough tutors for each group. Peer tutors check the functioning of each group, assure the quality of group discussions, and inform the instructor what is working well and what is not. Finally, in the large class models, additional structure is designed into group activities. For example, instead of twenty-minute period of group discussion, two ten-minute period group discussion with whole class discussion or a minilecture in between are used. As Duch (2001) pointed out, a variety of factors, including size

of class, intellectual maturity and motivation level of students, availability of peer tutors or graduate assistants, should be considered in incorporating PBL in class.

Effects of PBL

In traditional lecture-based instruction, students passively receive the teacher's knowledge, memorize facts that are usually forgotten after some time, and have difficulty in applying acquired knowledge to solve real-world problems. PBL aims to avoid such problems by placing students in an authentic, problem-oriented, and learner-centered environment. Many studies have shown the positive effects of PBL on learning. According to Barrows and Tamblyn (1980) and Norman and Schmidt (1992), PBL fosters self-directed learning skills, attempting to help students to be life-long learners and be able to independently approach complex problems they will face in their professional life. Studies also support that PBL promotes more in-depth understanding of content (Coles, 1985; Newble & Clarke, 1986; Vernon & Blake, 1993) as well as the retention and application of knowledge acquired (Berkson, 1993; Norman & Schmidt, 1992). In addition, both students and teachers appear to enjoy learning and teaching in PBL (Albanese & Mitchell, 1993).

Critics generally argue that PBL sacrifices breadth for depth of content, resulting in the lack of knowledge acquisition. However, in fact, the results of studies examining the effects of PBL on knowledge acquisition are inconclusive. The review of literature from 1972 to 1992 conducted by Albanese and Mitchell (1993) revealed that PBL students performed better than students who received traditional instruction on clinical examinations, whereas they scored lower on basic science examinations than their conventionally trained counterparts. Vernon and Blake (1993) also found from synthesizing all available studies from 1970 to 1992 that conventionally taught students performed significantly better than PBL students on the National Board of

Medical Examiners (NBME) Step 1, while the scores of both groups on miscellaneous tests of factual and clinical knowledge were not significantly different. However, the findings of literature reviews conducted by Berkson (1993) and Colliver (2000) showed similar achievement between PBL students and conventionally taught students. In addition, Blake, Hosokawa, and Riley (2000) found that PBL classes performed substantially better than traditional classes in both basic science and clinical examinations.

It appears that the studies regarding the effects of PBL are problematic in several ways (H. S. Barrows, 2000). First, many studies do not address whether there is a difference between traditional instruction and PBL with regard to the acquisition of such skills of problem-solving skills or reasoning that PBL values, using inappropriate assessment methods in examining the effects of PBL and. Gijbels et al. (2005) conducted a meta-analysis to investigate the influence of assessment on the effects of PBL. They found that PBL had the most positive effects when the focus of the assessment were at the level of understanding the principles that link concepts, rather than at the level of understanding of concepts or at the level of linking of concepts and principles to conditions and procedures for application. The results suggest that the implications of assessment must be considered in examining the effect of PBL.

Second, most studies overlook the fact that application of PBL may be different case by case. Barrows (2000) noted that PBL curricula can differ remarkably according to the extent of the curriculum that is problem-based, the problem formats, the size of student groups, the kinds of subjects or disciplines, the degree to which conventional curricula compete with PBL, the assessment methods, and so forth. Therefore, drawing conclusions by synthesizing the results of the studies of many different PBL cases can be erroneous.

Finally, claims about the effects of PBL seem to rely almost exclusively on literature in

medical education. Although PBL originated in medical education, it has been applied in diverse disciplines. We need research on the effects of PBL in many other disciplines.

PBL in Online Environments

With the rapid growth of computer technologies, there have been attempts to combine PBL with computer-supported collaborative learning (CSCL). Initially, local area networks were used to support PBL (Koschmann *et al.*, 1996). Nowadays, the Internet makes it possible to implement PBL in online environments, and the notion of distributed problem-based learning (dPBL) has emerged. A number of researchers have offered examples of dPBL courses designed based on some basic assumptions of the general PBL model developed by Howard Barrows on the one side, and computer-supported collaborative learning (CSCL) tradition on the other side (Koschmann, 1996). In addition to the term dPBL, other similar terms such as computer-mediated PBL or online PBL are also used. The term online PBL will be used throughout the chapters.

What is online learning?

Often referred to as Web-based learning, online learning means e-learning over the Internet as opposed to other networks such as local or wide area networks (eLearners.com). The main feature of online learning is that it enables learners to learn anytime and anywhere via the Internet, using e-mail, electronic bulletin boards, online chat rooms, and so forth.

The term of online learning is used interchangeably with the term of e-learning. However, strictly speaking, e-learning is a broader concept that covers online learning. According to Wikipedia, an online encyclopedia, e-learning refers to "an approach to facilitate and enhance learning through the use of devices based on computer and communications

technology." In other words, e-learning, which is technology-based learning that uses a broad range of technological device from CD-ROMs to the Internet, includes computer-based learning and online learning or Web-based learning.

Why is online learning important for PBL?

An online environment has a number of features that are favorable for PBL. First, computer-mediated communication (CMC) in online learning provides students with more time to analyze and reflect on the content and to compose thoughtful responses (Althaus, 1996). The permanence of online discourse allows students to print out discussions and fosters student reflection (Bonk & King, 1998). Facilitating reflection and reasoning is critical in PBL.

Second, online learning enables students to take control of their learning in a more decentralized and constructivist environment where the role of instructor becomes a coach rather than a main source of information (Vrasidas & McIsaac, 2000). This feature is consistent with the learner-centered approach in PBL.

Third, online learning promotes interactions and collaboration among the instructor and students (Relan & Gillani, 1997) and engages students in higher level thinking through active and interactive learning (Harasim et al., 1997). This feature is also well suited for PBL in that PBL depends on collaborative learning.

Fourth, an online environment provides an easy access to rich and dynamic resources and opportunities to receive advice or mentoring from a variety of resources, such as experts, practitioners, and peers (Bonk & King, 1998). The rich resource environment can be very helpful in PBL where students search for needed information and knowledge through self-directed learning.

Fifth, CMC can provide a more comfortable environment and discussion opportunities for students who do not perform well in spontaneous face-to-face discussion because they are shy or because their native language is not English (Berge & Collins, 1993; Harasim, 1990; Leasure *et al.*, 2000). Many studies have shown that low participants and shy students tend to participate more online than they do in face-to-face settings. (Bonk & King, 1998; Chong, 1998; Cooney, 1998). By enabling all students to actively participate in discussions regardless of their personality, an online learning environment may foster generating more ideas or multiple perspectives in problem solving.

Finally, there are less off-task behaviors online (Angeli *et al.*, 2003; Bonk *et al.*, 1998a; Bonk & King, 1998; Bonk *et al.*, 2004). Thus, an online environment has a potential of having students focus on problem solving tasks and solve problems more efficiently.

Disadvantages of online environments and PBL

It is important to understand the disadvantages of an online environment that might affect PBL, as well as its advantages. Thus I will address general problems of an online environment and discuss their implications for PBL below.

First, computer-mediated communication (CMC) in online environments lacks visual and auditory cues (Vrasidas & McIsaac, 2000). In a face-to-face learning environment, the instructor can discern whether students understand or not from their facial expressions, body language or gestures. CMC lacks such contextual cues. Thus, the level of student confusion tends to be high, and online learning requires clear guidance and structure (Bonk & King, 1998; Dennen, 2000). Considering both learner-centered nature of PBL and the need for structure in online learning, the degree of structure in online PBL seems to become an important issue.

Second, online learners usually have a full-time job and are likely married (Thompson, 1998). Therefore, it might be very hard for them to collaborate with peers online as they do in face-to-face settings. Although online learning, which is place and time independent (Harasim, 1990), enables working in convenient places with highly flexible schedule, collaborating with others with different learning schedules in online environments could be frustrating. The consideration of the strategies for fostering online collaboration is essential in designing and implementing PBL in online environments, since PBL highly depends on collaborative learning.

Third, it appears that it takes more time to complete communications or tasks when using CMC. Bordia (1992) found that CMC groups took longer than face-to-face groups to complete the same tasks from a meta-analysis of eighteen studies comparing CMC and face-to-face groups. Walther (1996) also noted that the main difference between face-to-face communication and CMC is communication speed. Moreover, text-based asynchronous CMC can be overwhelming to students when there are large numbers of messages to read and respond to (Wooley, 1998). Therefore, there is a need for understanding the features of CMC and for finding ways to make CMC effective and efficient for online PBL, since the quality of PBL depends on discussion and communication.

Fourth, students tend to be too nice to one another online (Bonk & King, 1998; Bonk et al., 2004). Such tendency might degrade the quality of discussion in PBL. However, diverse instructional strategies can be used in order to spur discussion. Bonk and King (1998) suggests developing controversies and conflict by assigning roles such as pessimist, devil's advocate, and idea squelcher, to spur discussion.

Finally, students often fail to justify their claims online (Angeli et al., 2003; Bonk *et al.*, 2001; Duffy *et al.*, 1998), relying on personal opinions or anecdotes (Bonk *et al.*, 1998b). Since

argumentation or justification is critical in problem solving (Cho & Jonassen, 2002; Kuhn, 1991), implementing PBL in online environments might require employing some scaffolds or tools for argumentation.

Empirical research on online PBL

PBL and collaboration

Research has shown that collaboration has a positive effect on problem solving in face-to-face settings. Will the collaborative problem solving approach also be effective in online environments? Some researchers realized that the collaborative problem solving in online environments would be very difficult since face-to-face interaction is not available and learners work at their own pace, and so they developed an instructional design model for individual online PBL (Malopinsky *et al.*, 2000). On the other hand, there has been an effort to determine if the positive effect of collaborative learning on problem solving in face-to-face environments will also be obtained in online environments. Uribe, Klein, and Sullivan (2003) investigated the effect of computer-mediated collaboration on solving ill-defined problems, and found that learners who worked in computer-mediated collaborative dyads performed significantly better than did ones who worked individually. Their finding indicates that the benefit of collaboration for problem-solving in face-to-face learning environments transfers to online environments. However, considering that computer-mediated collaboration in their study included only synchronous communication in a computer laboratory, the result may be applicable to limited settings. Additional empirical research is required to validate the effect of collaborative learning on problem solving in online environments.

In regard to the collaborative group size in an online PBL environment, Uribe and Klein (2003) hypothesized that as the number of members of a collaborative group increases, the

positive effect of collaboration on problem solving may decline, because, in a synchronous computer-mediated communication system where users often talk simultaneously, as the number of users increases, the confusions from the simultaneous communications that may inhibit problem solving become greater. As they expected, their study results showed that learners who worked in dyads performed significantly better in solving ill-defined problems than those who worked in teams of four. More specifically, learners who worked in dyads communicated more, generated higher number of possible solutions, had higher quality interactions, and consequently performed better than those who worked in teams of four. The result indicates that grouping learners into teams of more than two may not be a good strategy when implementing PBL in online environments. This study is insightful in that it challenges general practice. It is generally known that three to six members are most effective in small group learning (D. W. Johnson & Johnson, 1997; Putnam, 1997), and we often group learners into teams of at least three or four in both face-to-face and online environments. It may be possible that the optimum size of an online collaborative group is different from the one of a face-to-face collaborative group. However, we cannot be sure whether the same result will be obtained in different online collaborative environments. For example, if we investigate collaborative problem solving through an asynchronous communication system, instead of a synchronous system, the result may be different. Additional research on the appropriate size of an online collaborative group is needed.

There has been an interest in inter-group collaboration for problem solving beyond intra-group collaboration. Lou (2004) found that between-group collaboration in project-based online courses improved group processes and group project performance in complex problem solving, by allowing students to share a variety of problem-solving challenges and strategies with other

groups and to observe the different consequences of different strategies. The study suggests including inter-group collaborative learning strategies as well as intra-group collaboration in a future collaborative online PBL model.

Structure of Collaborative Problem Solving Process

Online PBL seems to require more rigid structure than PBL in face-to-face environments. Most researchers who studied on online PBL or developed models for online PBL appear to believe that a fairly strict structure of problem solving process is critical for successful implementation of online PBL. Orrill (2002) used a framework of four phases that set milestones for learners. Phase 1 of the framework included the problem formulation, self-directed learning, and reflection activities. Phase 2 and 3 focused on research and planning. Phase 4 involved the development of a deliverable. Steinkuehler et al. (2002) built a strongly structured network environment that guided learners into a fairly strict sequence of a number of activities of the PBL process. They expected that making the structure and expectations clear in the beginning will allow learners to become familiar with the general procedures and consequently to be able to make their own decisions on how to structure their group activities. According to them, as learners become familiar with the process, the scaffolds are faded.

In a similar vein, Dennen (2000) highlighted the importance of task structuring in online PBL. She explored an undergraduate educational computing course where students worked on three projects in collaborative groups, communicating through asynchronous Web-based conferencing software. In her study, it was observed that the instructor moved from less structured to more structured tasks over the course of the semester. In other words, the guidelines for the three projects gradually became more structured and specific in terms of tasks to be completed and their deadlines. However, it was noted that the approach of moving from

less structure to more was not intentional or planned beforehand. The instructor modified plans between problems based on the students' reactions. The increased task structuring appeared to improve learner performance in terms of both process and product over the course of the three projects. The instructor also realized that the quality and timeliness of student work as well as group collaboration was improved with highly structured assignment parameters.

Although many studies suggest that online PBL process have more rigid structure than PBL in face-to-face environments, there is also an exception that shows a different case. McConnell (2002) examined the collaborative problem solving process of learners in an online PBL course. All learners were professional educators interested in distance learning, and the course was very lightly structured. However, the loose structure appeared to work quite well in the course. It may be because the learners, as professionals, were highly motivated and committed to the project, which was directly related to their professional work. The results of the study presented that there were distinct phases, which were not planned beforehand but created by the learners in the collaborative problem solving process: negotiation, division of work and research activity, and production. These phases were not completely discrete. Rather, they tended to occur partly simultaneously with iterations of some activities. The interesting point is the time used for each phase. The learners took a great deal of time in the first phase, negotiation, and hurried in the final phase to meet the deadline. These findings imply that some task structuring might have improved the problem solving process by guiding the learners to use their time more effectively.

Overall, it seems that a fairly strict structure and guidelines are needed in online PBL. The structure could be either for the whole problem solving process or for tasks involved in the process. However, there are not sufficient empirical data to validate it. As we can see in the

case of McConnell (2002), a loose structure might work well if learners are highly motivated and take initiative in their learning. That is, the structure could vary according to specific situations of the learning environments. Therefore, we should conduct more research on the structure of online collaborative PBL process, considering a variety of variables, including learner motivation, prior knowledge and experience of learners, class size, and so forth.

Scaffolds and Tools for Supporting Collaborative PBL

Educators have created tools for supporting collaborative problem solving, such as Project-Based Learning Support System (Laffey *et al.*, 1998) and WISE (Bell, 1997). However, most tools have been designed for K-12 learners in face-to-face environments. In response to the need for tools to support adult learners engaging in online PBL, Orrill (2002) helped develop the Asynchronous Conferencing Tool (ACT) (Duffy et al., 1998), which included a discussion space with a labeling system, and examined the ways four groups of graduate students in two graduate-level education courses used the tool in their collaborative problem solving process. As a result, he found that learners tended to use the tool for logistics, posting messages about due dates, deliverables, and organizing reports, rather than using it for problem solving itself. This indicates that we need to find ways to support both problem solving process and logistics involved in the process more effectively. How can we support learners to focus more on problem solving, and at the same time support the logistics? There should be research on this issue. Orrill (2002) also found that learners used the labels in unexpected ways, developing new definitions of the labels within the group and their messages often contained up to five or six idea units. As Orrill (2002) mentioned, adult communication is often so complex that each message contains many idea units, which belong to several labels or categories. In this respect, there should be careful considerations about using a labeling system for adults. There is also a

need for more investigation on the ways to facilitate metacognitive processes of adults without limiting their natural communication patterns (Orrill, 2002).

Cho and Jonassen (2002) examined the effect of online argumentation scaffolds on problem solving, especially ill-structured problem solving, by comparing the groups who used only BBS to collaboratively solve their problems and the groups who used a constraint-based argumentation tool, Belvedere, to structure their arguments and discussions in the problem solving process. The participants were undergraduate students in an introductory economics course. As a result, they found that the use of the argumentation scaffold resulted in significantly more problem-solving actions, as well as increasing the generation of coherent arguments. In addition, the effects of the argument scaffold appeared to transfer to the creation of arguments during individual problem-solving. This study showed that we can facilitate problem solving process by supporting the generation of coherent arguments, which is an important skill in solving problems.

Most tools and scaffolds for facilitating PBL have been developed for learners. However, when we think about the work of facilitating PBL, we realize the need for tools or support systems for facilitators. Facilitating PBL involves diverse skills and tasks from monitoring learner activities and group processes to probing learner knowledge to challenging learner thinking, which may be very challenging to instructors who are accustomed to traditional directive instruction. Furthermore, facilitating online PBL requires additional skills, including technical skills, and more time. Thus, it appears that finding enough PBL facilitators who have appropriate knowledge and skills is a major problem in current higher education settings (Steinkuehler et al., 2002). In many cases, TAs with little or no experience in a PBL context support small groups in PBL courses. For the purpose of assisting such PBL facilitators,

Steinkuehler et al. (2002) developed the STEP problem-based learning system where many of the usual facilitator tasks and responsibilities are distributed across the system and learners. For example, the system enables learners to guide themselves through PBL activities through the three-session design, monitors learners' progress and insures that each learner has paid adequate attention to each phase by providing access to the next session based on adequate completion of prior tasks. The STEP pbl system also provides facilitators with online tools and resources that can assist and scaffold tutoring multiple online groups at once, as well as accumulated wisdom, practical knowledge and strategies, and examples (e.g., model questions for probing student knowledge and reasoning), which have been developed over time.

Although there is no question about the importance of scaffolding in problem solving, current research indicates that not all scaffolds have a positive effect on problem solving. For example, Ge and Land (2003) found that question prompts had significantly positive effects on ill-structured problem solving but peer interactions did not have significant effects. Their study suggested that the peer interaction process itself must be guided and monitored with various strategies, including question prompts, in order to maximize benefits, since learners may interact with each other at a very basic level without appropriate guidance. Although the study was not about online PBL, the findings provide valuable insights about the use of scaffolds in problem solving. It would be very interesting to explore the kinds of scaffolds that might have a positive effect on collaborative problem solving in online environments.

Saye and Brush (2002) identified two types of scaffolds to guide students to solve ill-structured problems: (a) hard scaffolds and (b) soft scaffolds. Hard scaffolds refers to "static supports that can be anticipated and planned in advance based on typical student difficulties with a task" (Saye & Brush, p. 81). In contrast, soft scaffolds are human beings who can provide

dynamic, situational and timely support based learner responses. In terms of the types of scaffolds, research on the scaffolds for online PBL seems to focus on hard scaffolds. Future research should not overlook the importance of soft scaffolds.

Closing Comments

The existing knowledge base on PBL in online environments has addressed the issues of collaboration in online PBL, structure of problem solving process in online environments, and tools and scaffolds for supporting online PBL, and others. More specifically, such topics as the effect of computer-mediated collaboration on solving ill-defined problems (D. Uribe et al., 2003), the size of collaborative groups (D. Uribe & Klein, 2003), intra-group collaboration (Lou, 2004), structuring the problem-solving process (Dennen, 2000; Malopinsky et al., 2000; McConnell, 2002; Orrill, 2002; Steinkuehler et al., 2002), labeling systems for facilitating metacognitive processes in problem solving process (Orrill, 2002), and the effect of online argumentation scaffolds on problem solving (Cho & Jonassen, 2002) have been discussed in current literature on PBL in online environments.

Although current literature provides interesting and useful insights and guidance, it does not provide the whole picture of online PBL, focusing on some parts of it. The tendency that most online PBL courses appear to be simple duplications of face-to-face PBL courses is partially due to the lack of comprehensive theory or guidelines for designing and delivering online PBL. PBL is very complex because it involves a number of learner activities. In order to design effective PBL experiences that are appropriate for online environments, and implementing them successfully, we need more comprehensive guidelines. Therefore, we should develop comprehensive, systemically interrelated guidelines that are useful to professors and

teachers. Recognizing that every situation is unique in some ways, the guidelines also need to be situational. In essence, the guidelines need to identify when the methods should and should not be used. Therefore, the research question and sub questions guiding this study are as follows: What guidelines are useful for designing and implementing collaborative PBL in an online environment?

- How is collaborative PBL implemented in an online environment? How does the instructor structure and facilitate collaborative PBL?
- What strategies work or do not work under what conditions? What are the strengths and weaknesses of collaborative PBL?
- How can collaborative PBL be improved?

CHAPTER III.

METHODOLOGY

Research Design

The purpose of this study was to develop a design theory or guidelines for designing and implementing collaborative PBL in online environments. Thus, the formative research methodology developed by Reigeluth and Frick (1999), which is a kind of qualitative case study (Stake, 1995; Yin, 2003), and grounded theory (Strauss & Corbin, 1994) methodology were adopted.

The formative research, as a research methodology for improving an existing instructional-design theory or for developing a new grounded theory, entails asking such guiding questions as "What methods worked well?" "What did not work well?" and "How can it be improved?" The methodology uses a case study approach and can be used for both designed cases and naturalistic cases: A designed case refers to an instance that was created using the design theory of interest, while a naturalistic case refers to an instance that was not designed according to the design theory of interest. For the naturalistic cases, the methodology varies according to whether the research is conducted while the instance takes place (in vivo naturalistic cases) or after the instance has already taken (post facto naturalistic cases). Thus, the methodology offers six variations (see Table 1).

Table 1. Kinds of Formative Research Studies

	For an Existing Theory	*For a New Theory*
Designed Case	Designed case for an existing theory	Designed case for a new theory
In Vivo Naturalistic Case	In vivo naturalistic case for an existing theory	In vivo naturalistic case for a new theory
Post Facto Naturalistic Case	Post facto naturalistic case for an existing theory	Post facto naturalistic case for a new theory

This study used *in vivo* naturalistic cases for developing a new theory. The formative research method of an *in vivo* naturalistic case for a new theory requires the following process:

1. Select a case.
2. Collect and analyze formative data on the case.
3. Fully develop your tentative theory.

According to the method and utilizing multiple case studies, this study selected three cases, collected and analyzed formative data as well as descriptive data on the cases, and proposed guidance for designing and implementing collaborative PBL in online environments.

1. Select a case.

Sampling Strategy. Purposeful sampling, which is the dominant strategy in qualitative research and seeks information-rich cases for in-depth study (Patton, 1990), was used in this study. Patton (1990) identified a number of types of purposeful sampling. They include extreme or deviant case sampling, intensity sampling, maximum variation sampling, homogeneous sampling, typical case sampling, critical case sampling, snowball or chain sampling, criterion sampling, theory-based sampling, and others. Among these, the researcher used criterion sampling where all cases that meet some predetermined criteria are selected. The criteria for course selection were as follows:

- The course should be offered online and use computer-mediated communication (CMC) for discussion and any other activities associated with problem solving.
- The course should use an authentic, complex, and ill-structured problem(s) as the stimulus for learning.
- The course should use a learner-centered approach: The instructor should play a role of a facilitator or tutor and help learners engage in self-directed learning.
- The course should help learners acquire both domain-specific knowledge and domain-independent knowledge, such as problem solving, reasoning, metacognitive, and communication skills.
- The course should require learners to solve a problem collaboratively in small groups.

Cases. In order to find out who was using PBL in online courses, the researcher asked professors, contacted many university departments or programs and authors of relevant articles, and also searched the Web. From the search, the researcher found a number of university-level courses utilizing online PBL. The researcher sent emails to the instructors of the courses with information of this study and asked them whether their courses fit this study and also whether they were willing to participate in this study. Three graduate-level online courses that met all selection criteria were selected: (1) "Technology: Use and Assessment," (2) "Introduction to Reference," and (3) "Advanced Problems in Librarianship: Collection Development." These cases will be described in detail in the following result chapters.

2. Collect and analyze formative data on the case.

Data Collection. From each case, two kinds of data were collected: descriptive and evaluative. These data were collected from multiple sources, including interviews, observations,

and document review (triangulation). The data collection began in the beginning of the Fall 2005 semester and ended about two weeks after the end of the semester. Each of the data sources is described next.

Virtual Observations. The researcher conducted virtual observations of the three online courses throughout the fall 2005 semester, mostly reading asynchronous discussions. For the third case, the researcher also read and listened to archives of synchronous communications and attended a synchronous class meeting. Throughout the semester, the researcher documented interpretations and impressions she got during observations.

Instructor interviews. The researcher interviewed each instructor twice via telephone, once during the course, and once at the end of the course. Each interview took about 30 to 60 minutes and was recorded for analysis with a digital voice recorder. A semi-structured interview protocol, a list of questions, was used. Therefore, the interview was not restricted to the predetermined questions, depending on the instructor's response. During the interview, the researcher took notes. Further questions followed via email when clarification or elaboration was needed.

Sample interview questions were:

- How did you form the small groups? Why? What do you think is the optimum size of a small group for online PBL?
- What kinds of strategies did you use to facilitate the problem-solving process?
- What strategies worked and didn't work well?
- How did you help the students' self-directed learning and research?
- What would you like to change in order to improve collaborative PBL in your course?

Student interviews. Student interviews were conducted after the semester was over between December 13 and December 19 in order to collect data about their experiences with, opinions about, and reflections on online PBL, as well as data about how they would want to improve the problem-solving process. One student from the first case, two students from the second case, and three students from the third case participated in interviews.

Sample questions are:

- What did you like and dislike about the PBL activity or assignment? Why?
- Can you describe the problem-solving process your group went through?
- What kinds of problems or difficulties did you have in the collaborative problem-solving process?
- What could the instructor have done differently to facilitate online collaboration for the PBL activity (or assignment) more effectively?
- What would you recommend to improve the PBL activity?

Document review. Course documents such as course syllabi, learning resources, student reports, and reflection papers were collected for review. Document review was the primary method for collecting descriptive data. However, such document as reflection papers yielded some formative data.

Data Analysis. Data analysis was intertwined with data collection. In other words, early data analysis affected later data collection, and the process of data collection and analysis was cyclical and emergent in nature (Patton, 1990).

Qualitative data from each case were analyzed using the constant comparative method (Glaser & Strauss, 1967; Strauss & Corbin, 1990), which involved joint collection, coding, and analysis of data. According to the method, the researcher first broke down emerging data into

discrete parts and coded each part into a category, comparing them with other previously coded parts (open coding). Next, the researcher integrated categories to make connections between them (axial coding). Finally, the researcher selected and identified the core category and systematically related it to other categories (selective coding). After analyzing data of each case, cross-case analyses were conducted.

3. Fully develop a tentative theory.

An instructional-design theory consists of instructional methods and instructional situations (Reigeluth, 1999). Reigeluth (1999) emphasizes that instructional methods in an instructional-design theory are situational rather than universal. In other words, one method may work well in one situation but may not work in another situation. The researcher developed tentative guidelines for designing and implementing collaborative PBL in online environments based on analyses of the findings from this study, combining instructional methods and situationalities.

Methodological Issues

Trustworthiness

Trustworthiness was enhanced in several ways. First, triangulation of data by data source was used to help establish credibility (Lincoln & Guba, 1985). Second, member checking (Lincoln & Guba, 1985; Stake, 1995) was conducted to ensure accuracy of the findings. The researcher requested participants to review her interpretations and encourage them to correct inaccurate interpretations and provide alternative words. Third, the researcher provided important raw data to enhance credibility of the study. Finally, the researcher explored possible conditions that may restrict the generalizability of the guidelines developed based on this study.

Transferability or generalization

Transferability, parallel to external validity in quantitative research, refers to the degree to which the results of qualitative research can be transferred or applied to other situations (Lincoln & Guba, 1985). In qualitative research, the reader is responsible for transferability. In other words, the reader makes his or her own generalizations based on the information given in the study and applies the findings to his or her own context if appropriate. The researcher's responsibility is to provide extensive and careful detail, known as thick description, to enable the reader to make such a judgment (Lincoln & Guba, 1985). The researcher tried to enhance the transferability of this study by providing thick descriptions of each case. The use of multiple cases also enhanced the transferability of this study (Yin, 2003).

CHAPTER IV.

CASE 1: PBL IN "TECHNOLOGY: USE AND ASSESSMENT"

This chapter presents the results from analyses of both descriptive and evaluative data collected from the first case, a graduate course in the Industry and Technology field. The findings were organized around the following research question and sub questions:

What guidelines are useful for designing and implementing collaborative PBL in an online environment?

- How is collaborative PBL implemented in an online environment? How does the instructor structure and facilitate collaborative PBL?
- What strategies work or do not work under what conditions? What are the strengths and weaknesses of collaborative PBL?
- How can collaborative PBL be improved?

To begin, general information about the case is provided. Second, how collaborative PBL was implemented in the course and what happened in the PBL are described. Third, the strengths and weaknesses of collaborative PBL in the course are presented. Lastly, how collaborative PBL in the course could be improved is addressed.

Case Description

"Technology: Use and Assessment" was a three-credit-hour graduate course (see Table 2). It was offered completely online by the Department of Industry and Technology at Ball State University during the Fall semester 2005. Blackboard 6 was used as the course management software. As the course title indicates, this course examined issues related to technology use and

technology assessment, including product usability, usability research, usability testing, technology assessment techniques, and environmental impact assessment.

The Technology Use part was covered during the first six weeks. The instructor used a fairly structured approach for this part. He made four additions to online materials every week, usually by Monday night. First, he posted a new announcement in Blackboard. Second, he updated the Weekly Assignments page with one or two assignments for the week. Third, he provided new modules or lessons on the Learning Modules page. Finally, he opened a new discussion board forum in Blackboard for whole-class discussion.

On the other hand, the problem-based learning (PBL) approach was used for the Technology Assessment part. During the problem-solving process, there was neither a module nor whole-class discussion. Although the Weekly Assignments page was still used, it was used for providing organizational scaffolding rather than informing about new assignments.

There were nine students, all of whom were Master's students in Technology Education. Six of them were technology teachers in K-12. These students were from six different states. The instructor of the course was a Professor and Director of Online Education in the Department of Industry and Technology. He taught eight online courses, including this course, and used PBL in every one of his online courses.

Table 2. Contextual Information for Case 1

Case 1: Technology: Use and Assessment	
Level of learning	Graduate
Learning content	Technology use and technology assessment
Course management system	Blackboard
Use of PBL	PBL was used for the Technology Assessment part.
Amount of PBL	Six weeks
Number of students	Nine
Amount of experience instructor had with online PBL	The instructor had taught eight online PBL courses, including this course.

Implementation of PBL in the Technology Assessment Part of the Course

Background information and examples. In Week 7, the instructor provided an overview of Technology Assessment (TA) and a number of examples of TA reports in the Learning Modules page. He also asked the students to select one of those reports and to post a summary and critique of it on the discussion board forum. In Week 8, the instructor offered brief descriptions of 18 TA techniques. He emphasized that the information given was insufficient for actually performing a technology assessment, stating that "the purpose of this lesson is to just scratch the surface," and he informed that individual students would need to explore the techniques in greater detail as well as other alternatives through their own research.

Problem presentation. In Week 9, the instructor presented a problem in a letter, which was assumed to be written by Pete V. Domenici, who was the Chair of the US Senate Committee on Energy & Natural Resources, to formalize the award of a contract between that Committee and a company for the production of a TA report. The award letter was created by the instructor.

In the letter, Senator Domenici first addressed problems of future residential heating resulting from our population growth and our growing dependence on a non-renewable energy source. Then he requested "a thorough analysis on technologies that are currently available and those that likely could come into use over the next fifty years." In particular, he requested the "facts" about home heating technologies and "alternative policy options" that look 50 years ahead.

> We need the facts about different technologies for home heating, along with the facts about reserves of fuel used by these technologies. … Second, we would like you to elaborate on alternative policy options for the US Senate Committee on Energy and Natural Resources. We propose legislation. That is our key role. Therefore, we want

> your report to inform us as we discuss whether to draft legislation on this issue over the next two months, and what that legislation would be. What are our best legislative options? One policy option we would obviously consider is a "do-nothing option." While your report might mention this for reasons of comparison, please select other alternatives for us to consider as the options you present…. (October, 17, 2005)

After presenting the problem to solve, Senator Domenici suggested the following: (1) the "facts" should be included in one or more co-authored chapters, (2) the number of "alternative policy options" should be determined by counting the number of authors on a team, (3) each option should have a different primary author, and (4) appropriate TA techniques should be used for each option. Citations from reputable sources were required for both "facts" and "alternative policy options." Senator Domenici also encouraged the students to consider diverse perspectives, by presenting the different points of view of the members of the Committee.

At the end of the award letter, Senator Domenici suggested that the report follow the format of US Office of Technology Assessment reports, use appropriate hyperlinks and graphics, and be published online. The award letter provided some structure by defining the client, providing the title of the final report, and specifying information needs and the format of the report.

Grading policy. After the problem presentation, the instructor addressed how the TA activity would be assessed. He intended to assess both process and product of the PBL by using three evaluations: (1) an evaluation of the quality or depth of thought involved in postings (and to some extent, the frequency of posts) in the group discussion board forums, which determined an "Individual Grade," (2) an evaluation of the final report, which determined a "Group Grade," and (3) a thorough analysis and evaluation of final reflection papers written by individual

students, which determined a "Reflection Grade." Forty percent of the grade (60 points) was to be taken from an Individual Grade, 40% (60 points) from a Group Grade, and 20% (30 points) from a Reflection Grade.

Group formation. The instructor assigned the nine students to three groups based on their previous grades or academic performance in this class. The top three students formed Team A, the next three students formed Team B, and the last three students formed Team C. A discussion board forum was given to each group. Regarding his strategy, the instructor stated that he preferred having homogeneous groups based academic performance for the following reasons.

> … it tends to help the top performers push even further, even deeper, and not spend a lot of their time helping others catch up work, while it helps the lower performers avoid lurking so they can't be ones who are latching onto others, because if they are all lurkers, no one's gonna do work … It can push both of them higher (December 8, 2005).
>
> If I create a heterogeneous group based on participation, there tend to be people who slack off and rely on other group members. But when I put those people together in one group, they are forced to participate.... (November 10, 2005).

Cognitive roles. The instructor assigned cognitive roles to the students. Since each group had three people, three cognitive roles were used: Inferencers, Possibility Generators, and Summarizers. These cognitive roles were also assigned based on previous academic performance (Rose & Flowers, 2003). The top student in each group was given the job the instructor believed to be the most demanding, and the lowest was given the least demanding job (December 8, 2005). Although the students were assigned to one of these three jobs, the

instructor pointed out to the students that all group members should be responsible for all of these cognitive jobs, paying extra attention to their special job. He created a discussion board forum for each cognitive job group to enable them to discuss and better understand their cognitive role.

Development of a common understanding of the problem. The students' reflection papers showed that understanding the problem was one of the most challenging parts in the TA activity. As two students put it:

> When the assignment was first posted to the board, I am quite sure that even though I read it, I didn't "really" read it. There was a lot of information that was located inside that document that didn't register with me until the third/fourth week. Being stumped about what direction to take and what research to really perform, I didn't know what direction to take. … (Julia, December 5, 2005).
>
> I knew that the biggest challenge during this project was going to be not just working together with people in different states (or in our case, time zones), but working together to understand and complete the project (Michael, December 5, 2005).

The instructor encouraged the students to read the award letter carefully, to question and evaluate the problem, and to develop a common understanding of the problem. He often raised a series of questions to help the students interpret the problem critically.

> So, what is your take on the award letter? Are there parts that seem contradictory? Are there parts that seem to have been omitted? If you were posing this problem for others, how would you have framed it differently? (October 17, 2005).

The students shared their own interpretations of the problem in their group and worked on developing a common understanding. However, their final reports showed that their

understanding of the problem was incomplete. The instructor hoped that the students would realize internal contradictions in the award letter and "suggest an even richer and more appropriate problem statement that the Senator would realize is even better than what he was thinking of." However, no one realized the internal contradictions contained in the award letter.

Learning through discussions. Throughout the TA activity, the instructor highlighted that the emphasis of the activity should be on learning through discussions, not on production of the TA report.

> As you work on this technology assessment activity, it is important to be focused on the goal. But what is the goal here? You might think the goal is publishing an online TA report, and that's partly right. But a larger goal is to learn about technology assessment, and that is the only reason you are working on writing a report. The real value of this activity will come from the dialogue you share in the discussion board forums (October 17, 2005).

He encouraged the students to engage in a meaningful dialogue by using their group discussion board forum as a "primary vehicle for communication and for learning together." In addition, he assigned 40% of the grade to the quality of the cognitive postings in the group discussion boards and reminded the students of it again and again.

Cognitive scaffoldings. In order to facilitate cognitive dialogue, the instructor provided guidelines, which were also used as the evaluation criteria for determining the individual grade, and he encouraged the students to evaluate their own postings based on the guidelines. The guidelines suggested raising new propositions, providing evidence to support those propositions, raising substantive challenges to propositions forwarded, making connections across different posts to relate concepts, and so forth. In addition to the guidelines, the instructor provided

cognitive scaffolding throughout the TA activity. He asked thought-provoking questions, raised new issues, and modeled critical thinking in the group discussion board forums. The instructor also tried to facilitate cognitive dialogue by providing situational guidance for cognitive jobs.

Some students contributed to their group's cognitive dialogue by sharing information and resources, providing critical feedback, forwarding propositions, and raising questions. However, their efforts were often discouraged by low participation of their teammates. The students often simply agreed rather than providing meaningful feedback. It was also observed that the students often did not provide appropriate explanation or justification for their argument.

The students did not play their cognitive roles successfully. The instructor originally intended that the students use their cognitive job group forums to discuss and better understand their cognitive role. However, the students discussed the problem, not their cognitive role, in their cognitive job forum (December 8, 2005). They generally talked about what their team was doing and shared information and resources with each other. Cognitive jobs seemed to contribute more to inter-group collaboration rather than to cognitive dialogue.

Synchronous meetings. In the middle of the Technology Assessment activity, Michael in Team A was frustrated with delay in their discussions and finally suggested that they meet synchronously. When Team A was looking for a way to discuss synchronously, the instructor recommended using Macromedia Breeze software and set up their synchronous meetings. Since he had a Macromedia Breeze account, he could host a meeting with video, audio, chat, whiteboard, and presentation panels. Team A had their first synchronous meeting on November 3, and it appeared to be very successful. They were very satisfied with the synchronous meeting with Macromedia Breeze and used it one more time near the end. Michael in Team A mentioned:

> Team A had a great collaboration session with Macromedia Breeze. We got a lot accomplished and set up our plan of attack and some other issues, stakeholders, etc. (November 4, 2005).

The instructor provided information on Macromedia Breeze to other groups as well and asked them to let him know if they wanted to use it. However, the other two groups did not want to use it. Two people in Team C decided to have a telephone conversation rather than using Macromedia Breeze. They talked on the phone a couple times. According to the summaries of their telephone conversations posted in their group discussion board forum, they divided up the work, set timelines, and made plans via telephone.

Organizational suggestions. The instructor provided organizational suggestions to make online communication more effective and efficient. First, he asked the students to post all communication in their group discussion forum. When the students communicated through email, chat, or phone, they had to post the discussion archive or summary of their discussions to the group forum to get credit.

The instructor also strongly suggested that the students always change the subject lines of their postings.

> One organizational suggestion, though, is that you always change the subject line of your messages, which facilitates later recognition of content when you are looking at a listing of 120 messages in this forum (October 20, 2005).

When he noticed that one group was creating their draft on Microsoft Word, he recommended creating the HTML page from the beginning to reduce their workload.

> In the past, those who have used Microsoft Word to create the report have found troubles later when trying to reformat the HTML page that is required, so I recommend

> using an HTML editor from the very start. This seems to decrease the amount of busy work later on for the group member taking on the task of posting the document (November 6, 2005).

The instructor also created one more forum for each group in the middle of the TA activity so that the students could use the new forum when the first forum was getting too crowded with old messages.

Are You On-Track? The collaborative problem solving process in this course was loosely structured in that the big six-week chuck of time was given without other milestones. The instructor expected the students to determine the appropriate problem-solving process themselves and set their own timelines (November 10, 2005). He believed that "the instructor should not know the process to be used" (November 10, 2005). However he provided organizational suggestions for those who needed more structure by providing an "Are You On-Track?" section every week on the Weekly Assignments page. With the "Are You On-Track?" he intended to "provide structure where the students feel they need more structure but not to impose the structure on them" (December 8, 2005). The following is an example of the "Are You On-Track?"

> Here are some friendly suggestions about what your team might be involved with this week. Your team's schedule might be different from this, but I'm hoping that providing these suggestions help rather than hinder… Decide on the format of the report, decide whose job it is to perform a particular technology assessment on a particular option, decide whose job it is to write each section of the report, establish deadlines for different sections of the report to be submitted to the team, devise a plan

> that solicits feedback from all team members and from others, as needed, on the report's draft(s)… (November 6, 2005)

Inter-group collaboration. Since all three groups were working on the same problem, the TA activity could have been a competitive activity. However, the instructor encouraged the teams to help each other and learn from each other rather than to be competitive.

> Part of the joy of this activity is to see the approaches taken by other teams. However, one of the major benefits to this "jigsaw approach to cooperative learning" is that it can be used to turn what were otherwise competitive groups into groups that help each other through their member's willingness to share… Look at it this way, each possibility generator might come up with, say, twelve different ideas for x, with nine of them in common with the other two teams. Without sharing, each team then considers twelve. But if they share, each team considers eighteen different ideas." (October 18, 2005)

Inter-group collaboration took place mainly in the cognitive job forums. Several students shared their team's progress, approaches and ideas in their cognitive job forum, and their ideas were sometimes used by other teams.

Collaborative writing. When the students were moving into the writing phase, the instructor was concerned about the tendency that students divide tasks and do isolated work on drafts. In order to make the writing a collaborative task, he emphasized the unity of the report.

> Please ensure that the report has unity. It should not look as if it were written by separate individuals, but by a real team that shares common understandings and goals. Therefore, your team should first discuss the issues, perform research, and co-author the common parts of the report. The choice of which policy options should be

> contained in the report should reflect group consensus, even though those chapters will have different individuals as primary authors (October 17, 2005).

Team B did an outstanding job of having unity in their report. In his feedback on their report, the instructor pointed out that each policy chapter had the same clear structure. On the other hand, Team A members adopted a different structure for their policy chapters and produced very inconsistent chapters.

Comments on TA reports. After the groups submitted their final reports, the instructor created a forum named "Comments on TA Reports," placed the links to the reports in the forum, and encouraged the students to look at other teams' reports and post comments. Although the same problem was given, each group produced a very different TA report. The students were amazed at the differences and could see what they missed and think about how they could have done it better.

> … It's interesting how a single topic can travel in several different directions… (Eric, December 6, 2005).
>
> I really like the format of your report. After completing our TA, I would have liked to cover the topics that you did instead of the ones that we did. Nice (Julia, December 5, 2005)
>
> After reviewing the other groups submissions, in comparison to ours, I feel that there were bits and pieces of each group's submissions that we could have incorporated into ours to make it that much more sound (Allison, December 5, 2005).

Reflection. After the final reports were submitted, the instructor asked the students to write a three-page, double-spaced reflection paper that was worth 30 out of 150 points. He suggested that they reflect on "what they have learned about the topic, about technology

assessment, about collaborating in an online team, about themselves, and about other areas that arose."

In the reflection papers, the students talked about how difficult it was to reach a common understanding of the problem and to find appropriate information from lots of resources available. They also often mentioned how frustrating it was to wait for other group members' responses and how helpful it was to have synchronous discussions. They discussed what they learned and what was especially interesting as well. The most interesting part of the reflection papers was where they talked about how differently they would approach the problem if they were given the same problem or a similar one again.

> If I wrote this document again, I would take a different path and come up with a completely different result. Looking back now, after seeing what else was done, I may have headed towards the direction of efficiency and conservation more. But, hindsight is 20/20… (Julia, December 5, 2005)
>
> There are many things that I would do differently if asked to complete another project like this, but the main thing would be to understand what my individual task was so that I would have more time to research and focus on the assessment (Michael, December 5, 2005).
>
> If I could do this project again, I would contact my group members via telephone earlier and get us all on the same page… (Jason, December 5, 2005).

Feedback and grades. The instructor spent a great amount of time on assessment to help the students learn more from his feedback. He provided very lengthy and detailed feedback to each student on their group report, on their contribution to cognitive dialogue, and on their reflection, with a grade for each. His feedback for each student was approximately four pages

long. In his evaluation of the final report, he pointed out eight to twelve strengths and weaknesses and also discussed how it could be improved. In order to determine individual grades, he copied and pasted all of the individual students' postings in the group discussion board forums to Microsoft Excel Sheet, counted the number of posts and words, and analyzed the contents very thoroughly based on the evaluation criteria previously mentioned. The instructor looked at both the quantity and quality of the postings, since some students posted many short messages, while others posted fewer messages containing more detail per message. His comments on individual students' postings included the participation level of the student, samples of organizational, social, metacognitive, and cognitive posts, and his feedback on the student's cognitive contributions. For the reflection papers, the instructor shared his thoughts on the students' reflection and raised issues for further learning.

The student assessment revealed that the students in general did not do a very good job in the TA activity: there was less cognitive dialogue in all forums than the instructor hoped; they performed poorly with their cognitive jobs; they failed to see the contradictions in the award letter and to redefine the problem; they did not respond to all the information needs noted in the award letter; and they did not use appropriate technology assessment techniques for the options they presented. However, the instructor believed that further learning in this class would happen when the students read his feedback, since he addressed what they missed (December 8, 2005).

It was expected that Team A would perform better than other groups. However, Team B got the highest grade, and Team A got the lowest grade for their final report, which was surprising. It was also expected that high performers in the previous assignments would participate more and perform better; however individual grades presented unexpected results.

In fact, the policy option chapter Allison authored in Team A was exactly what the instructor hoped to see. She was the only one who used appropriate techniques for the policy option presented. However, her group grade was low, so she received bonus points for her individual grade.

Strengths

Assessment for learning. The instructor highly emphasized that the focus of the TA activity be on learning through cognitive dialogue, not on production of the TA report, and he assigned 40% of the grade for the activity to individual contributions to cognitive dialogue. Although there was less cognitive dialogue in all forums than the instructor hoped, the students at least learned the value of cognitive dialogue and collaborative learning. The instructor's feedback on the activity also reflected his learning-centered approach and provided the students with opportunities for further learning.

Flexible structure. The instructor provided organizational structure for those who needed more structure through the "Are You On-Track?" section. It was flexible structure because it was not imposed but merely suggested only for those who needed it. In the loosely structured PBL environment where a flexible structure was given, the students not only could learn how to direct their own learning and acquire collaborative problem-solving skills by educating themselves about TA almost from scratch and determining their own problem-solving process and timelines, but also they could get guidance when needed.

Cognitive scaffolding. The instructor provided cognitive scaffolding throughout the problem-solving process by asking thought-provoking questions, raising issues, modeling critical thinking, and so forth. By monitoring the group discussion board forums often and carefully, he

figured out what was going on in each team, and he provided tailored guidance to facilitate their online discussions. The instructor's persistent efforts to facilitate cognitive dialogue encouraged several students, who were quiet in the beginning, and enabled them to propose a new idea, provide critical feedback, and raise important issues, even though no or late responses from their teammates often frustrated their efforts.

Synchronous meetings. Although synchronous meetings were not planned in this class, Team A wanted to meet synchronously, and the instructor set up two synchronous meetings with Macromedia Breeze for the team. It appeared to work very well. All three members of Team A talked about how helpful the synchronous discussions were for their team in their reflection papers.

> The Breeze program was instrumental in any success that we did have on this project. One of the hardest parts with this project was waiting on the other group members for a response within the discussion... With the program, we were able to instantly provide feedback and make progress. Some of this could have been accomplished through a conference call, which I believe another group tried, but the Breeze session also allowed us to look at the same information so that everyone was literally on the same page… (Michael, December 5, 2005).
>
> We accomplished a lot in our two Breeze sessions. I consider the Breeze sessions to be the most productive learning I've done online… It was an extremely helpful tool that I highly recommend and hope to use again (Eric, December 5, 2005).
>
> Another aspect of learning resulting indirectly from this Technology Assessment was from the software, Breeze, itself… This software, along with your dedication to make

> it available to us, really enhanced our ability to come together as a group and produce our final project (Allison, December 5, 2005).

The reflection paper written by Jason revealed that the synchronous discussions between two members of Team C through telephone were also very helpful.

> Communicating with a group basically through an online discussion board was extremely difficult. In the C group Melissa and I decided to talk on the phone a couple times in order to get our feet under us. Before we spoke and clarified some issues we basically wasted a week trying to get organized and figure out how we were going to attack this challenge… (Jason, December 5, 2005).

Weaknesses

Insufficient instruction. Before presenting the problem, the instructor provided an overview of the TA topic, examples of TA reports, and brief descriptions of common TA techniques. However, it seemed that his instruction was insufficient to prepare the students for the TA activity. Despite the information given from Week 7 to Week 8, the students did not know where to start and were very overwhelmed and intimidated. They often described their feeling of being overwhelmed in their forums.

> … I feel that there is just sooooo much information out there. I don't know where to begin or end for that matter, and I'm sure I'm going to miss some important information because the volume of information available is too numerous to detail it all (Allison, November 17, 2005).

The students did not have sufficient background knowledge and experience to solve the complex and highly ill-structured problem within six weeks. Consequently they did not pay enough

attention to important issues, they could not engage in quality discussions, and they could not produce what the instructor expected.

Improvements

Add practice. After the TA activity was over, the instructor thought it would be helpful if students practiced with one or more TA techniques before they engaged in problem-solving, and he decided to add some practice in his future class (December 8, 2005). A student also mentioned:

> There might have been a little bit more practice with the working with the technology assessment before actually having to try one yourself (December 13, 2005).

Increase group size. The instructor realized that a team of three was generally too small for the technology assessment activity. He felt that there might have been more postings and more dialogue if it had been larger. He therefore decided to "increase the group size from three to four" in order to improve online collaboration in his future class (December 8, 2005).

Have synchronous meetings. The instructor believed that it might have been better if they had had a synchronous meeting earlier at the outset to enable students to get familiar with each other. He also thought that synchronous meetings would be useful for decision-making times. A student who did not have a synchronous meeting in this class mentioned that it would be helpful if the instructor requires the synchronous meeting because "group members often don't have an initiative to do that" (December 13, 2005).

Show relevance. Although the students thought the problem was well presented in a real-world situation, they could not see how it could be related to their career. According to the course improvement survey the instructor conducted right after the course was over, the students

believed that the TA activity could be improved if it showed how it would affect them as teachers, how it could be used in their classroom, and how it would help their students.

Improve Blackboard. The instructor wished to see some improvements in the Blackboard system. He thought it would improve online PBL if Blackboard had audio, video, document sharing capabilities, cognitive tools such as mind mapping and forecasting tools, and a "slider indicator" for each student, ranging from "1 = way too little guidance from the instructor" to "10 = way to much guidance from the instructor," so students could move their slider between 1 and 10 and let him know their needs for structure or guidance.

Summary

This chapter has described how collaborative PBL was implemented in the first case, "Technology: Use and Assessment" course, presented the strengths and weaknesses of collaborative PBL in the course, and addressed how collaborative PBL in the course could be improved. The strengths, weaknesses, and improvements of PBL in the first case are summarized in Table 3.

Table 3. Strengths, Weaknesses, and Improvements of Collaborative PBL in the Technology Assessment Activity

Strengths	Weaknesses	Improvements
• Assessment for learning • Flexible structure • Cognitive scaffolding • Synchronous meetings	• Insufficient instruction	• Add practice. • Increase group size. • Have synchronous meetings. • Improve Blackboard.

CHAPTER V.

CASE 2: PBL IN "INTRODUCTION TO REFERENCE"

This chapter reports the results from analyses of both descriptive and evaluative data collected from the second case, "Introduction to Reference" in the Library Science and Information Services field. The findings were organized around the following research question and sub questions:

What guidelines are useful for designing and implementing collaborative PBL in an online environment?

- How is collaborative PBL implemented in an online environment? How does the instructor structure and facilitate collaborative PBL?
- What strategies work or do not work under what conditions? What are the strengths and weaknesses of collaborative PBL?
- How can collaborative PBL be improved?

To begin, general information about the course is provided. Second, how collaborative PBL was implemented in the course is described. Third, the strengths and weaknesses of collaborative PBL in the course are presented. Lastly, how collaborative PBL in the course can be improved is addressed.

Case Description

"Introduction to Reference" was a three-credit hour graduate course in the Library Science and Information Services program at Central Missouri State University (see Table 4). Since the focus of the Library Science and Information Services program was on the education of school librarians who work with K-12 students and teachers, the scope of this course was also

limited to K-12 school libraries. As an introductory course, it aimed to familiarize students with reference resources and to enable them to critically evaluate, select, and effectively use them.

This course was offered online for 16 weeks from August 24 to December 16 in 2005. However, it also had two on-campus sessions that were required by the school. Although the class started on Wednesday, August 24, the instructor started each week on a Saturday, having a long first week, so that those who did most of their work on the weekend could have more time to interact with other students. The class communicated asynchronously in the Main Forum in Blackboard.

There were six assignments, which were worth 75% of the grade: (1) an information source report (15%), (2) a reference observation (10%), (3) journal article summaries (15%), (4) web site reviews (10%), (5) an inventory assignment (15%), and (6) a reflection paper (10%). Problem-based learning was utilized for the fifth assignment, the inventory assignment. Along with these assignments, students were given two or three weekly assignments that required them to participate in asynchronous discussions. For the participation in weekly discussions, the instructor assigned 25% of the grade.

Table 4. Contextual Information for Case 2

Case 2: Introduction to Reference	
Level of learning	Graduate
Learning content	Reference resources for K-12 school libraries
Course management system	Blackboard
Use of PBL	PBL was used for one of six assignments, the inventory assignment.
Amount of PBL	Two weeks
Number of students	Five
Amount of experience instructor had with online PBL	The instructor had used PBL in this course for three years.

This course had five students in the 2005 fall semester. The students were master's students, and at the same time they were working full time as K-12 teachers or practicing school library media specialists. They were all from western Missouri. The instructor valued the students' knowledge and reasoning ability and encouraged them to share their discoveries, thoughts, opinions, and experiences throughout the course. She had used PBL in this course for three years (November 9, 2005).

Implementation of PBL in the Inventory Assignment Part of the Course

Problem presentation. The problem the students were asked to solve collaboratively in this course was to create a reference inventory for a new library. The problem was presented in the first week as one of the six assignments. In Week 2, the instructor described creating a reference inventory for a new school as "the problem that drives our course" in the Main Forum (September 3, 2005).

Information environment. Although the problem was presented in the first week, the instructor did not ask the students to solve the problem right away. For the first 12 weeks, she helped them gain prerequisite knowledge by "exposing the students to the information environment they need to solve the problem," and by "setting up a series of tasks that cause them to explore the environment" (November 9, 2005). Specifically, she created a new discussion board forum in the Main Forum every week, provided readings, resources, and two or three weekly tasks that engaged the students in thinking and discussion of the topic of the week. Examples of the weekly tasks include creating a concept map of the material in the readings, creating a lesson plan for teaching about the use of one of the resources in the readings, and sharing thoughts on information literacy.

For the first 12 weeks, the students learned about specific types of reference resources, reference service, teaching in the library, government documents, electronic resources, budgeting, and so forth. Some of them were not directly related to the problem. By providing what she called the "information environment" with basic resources and tools needed to solve the problem, the instructor intended to enable the students to focus on more creative parts when solving the problem. She believed that providing the "information environment" was critical in this introductory course. However, she mentioned that she might use a different approach for an advanced course where students have sufficient prerequisite knowledge (December 14, 2005).

Group formation. All five students were assigned to one group, since the instructor believed that four or five is an appropriate size for the particular problem. The instructor mentioned that she would form heterogeneous groups if she had a larger class. She believed that students could learn more when they worked with those who had different interests and different questions (December 14, 2005).

Problem details. As mentioned previously, there were two on-campus sessions, which were called Saturday classes, on October 29 and November 19. The Saturday classes were mandatory and met from 9:00 a.m. to 3:00 p.m. At the second on-campus session, the instructor provided details for the three parts of the problem. Part 1 was to select a particular level of a school, assume that the school had the smallest enrollment, and make a reference collection for the new school library with a level-3 budget (A level 3 school library collection meets the highest criteria for school libraries in Missouri in terms of quantity and content.). It was required to make selections from the newest copyright dates (Dewey sensitive areas) that still met the needs of the students and teachers in the curriculum selected. Part 2 was to compile a selection list for a financially challenged school library with one-half the budget of the library in Part 1.

Part 3 was to create at least one teaching activity for each type of reference resource. The students were asked to work on Part 1 collaboratively in a group, but to work on Parts 2 and 3 individually. Thus, the focus of this study was on Part 1.

Initial plans and just-in-time instruction. After discussing the problem details, the students were given about 20 minutes to get together as a group at the on-campus session. Four of them discussed the problem together and made initial plans for their problem solving by dividing tasks and making a rough draft of the introduction part of their report. One student missed the session because her daughter got hurt.

> To be honest with you, out of six hours, we probably only worked on it together as a team for maybe 20 minutes… We divided out our assignments, what each person would be responsible for. And we kind of did like a little rough draft of what would be the introductory part of Part 1. That's pretty much all we did (Rebecca, December 14, 2005).

Since the students did not have sufficient prerequisite knowledge on budgeting, the instructor provided instruction on budgeting and helped them gain some basic ideas on how they should budget when creating a reference inventory.

Collaborative problem solving in the Assignment 5 Forum. After the on-campus session, the instructor created the "Assignment 5 Forum" in the Main Forum and had the students collaboratively work on the problem in the forum. The student group communicated totally asynchronously in the forum. Only two weeks were given for solving the problem. No other milestones were given. The instructor monitored the discussion board every day to check that the students were doing what they were supposed to be doing (December 14, 2005), but she was not involved in the problem solving process at all.

According to data from student interviews and reflection papers, learning about the 9th grade curriculum appeared to be one of the mains tasks, since they decided to create a reference inventory for a new 9th grade center. However the students did not discuss what they learned about the curriculum or how they learned about it in their discussion board forum.

> One of the elements of this assignment that was most challenging was in being familiar with a 9th grade curriculum. This was unfamiliar territory to all but one student in our class. I found that I needed to review 9th grade curriculum before making any initial selections and then used this knowledge again when eliminating titles from our group selections… I consulted with a former Freshman center teacher about the content of the 9th grade curriculum in order to make better decisions… (Anna, December 9, 2005).

Their problem-solving process did not involve much confusion or struggle, contrary to what was observed in the first case. When learning issues were identified, they found needed information fairly quickly. After making main decisions, such as how much money should be allotted to each Dewey sensitive area and whether they would apply for grants, they basically worked on their own parts, passing a document back and forth. Since they divided the task by Dewey section, each student was responsible for adding a list of books for their Dewey sensitive areas. Thus, a considerable part of their collaborative problem solving was closer to cooperation than to collaboration. However, according to data from the student interviews and reflection papers, the students were able to learn different approaches to creating a reference inventory by observing others' selections and their justifications.

> It was nice to learn what other people were selecting and be able to see their choices. You know kind of compare… and you know surprises and things like that. Basically the collaboration was the best part of it… (Rebecca, December 14, 2005).

Since one student could not post her part within the given time because of her daughter's accident, the instructor extended the deadline by giving one more week.

Reflection. Writing a reflection paper was required as the last assignment, which was worth 10 % of the course grade. However, the students were asked to reflect on all assignments, not just the inventory assignment. There were no specific guidelines for the reflection papers. Only two of the students were willing to share their reflection papers with the researcher. For the inventory assignment, they briefly discussed what they learned in terms of content and what was challenging, but they did not address any reflection on their collaborative problem-solving process at all.

> Assignment 5 was our most intensive and time consuming of all the projects and assignments this semester… One of the elements of this assignment that was most challenging was in being familiar with a 9th grade curriculum… (Anna, December 9, 2005).

> The Inventory Assignment was a great project that took us through an assimilation of what could be considered an authentic learning activity. I learned what would be an acceptable portion of the budget to spend on reference materials, and with that budget I selected materials for a specific library in a specific situation… The justification of purchasing materials not only lies with meeting the standards of accessible inventory but the ultimate justification lies in collaborating with teachers and learning what their needs are (Rebecca, December 10, 2005).

Assessment. The grade for the inventory assignment depended on the quality of the final report. The problem-solving process was not considered in the assessment. The evaluation criteria were 4C's – Clear, Concise, Comprehensive & Correct – and the standards for School Library Media Specialists. According to the instructor, all the students did a good job, but those who included policy and selection statements got a higher grade (December 14, 2005).

Strengths

The problem was highly relevant to the students' careers. According to the instructor and student discussions in Blackboard, the problem of creating a reference inventory for a new library was closely related to the current or future career of the students. As a matter of fact, one of the students had to do exactly the same thing in the very near future for her job. Although the students worked on the problem at the end of the course for only three weeks, the problem drove their learning throughout the semester and enabled them to gain practical experience in solving a very relevant real-world problem they were likely to face or were already facing in their careers.

The information environment enabled the students to focus on more creative parts rather than on finding facts to solve the problem. For the first 12 weeks, the instructor prepared the students for the problem by providing an "information environment" where the students actively explored a variety of issues regarding reference and became familiar with basic resources and tools needed for solving the problem. Since the students who were taking this introductory course did not have sufficient background knowledge for solving the problem, the information environment was an efficient and effective way to enable them to gain requisite knowledge and to focus on more creative parts rather than on finding facts to solve the problem.

Weaknesses

The students engaged more in cooperation than in collaboration. The instructor did not consider the problem-solving process in her assessment. Since the focus of the PBL was on the report, the students did not pay much attention to collaborative learning. They shared some ideas and resources, asked questions to each other, discussed issues, and made plans and decisions together. However they seemed to do these things only when they had to. Although they learned different approaches to creating a reference inventory from one another, it was from observing each other's selections and explanations after they finished their own part, rather than from discussions. They engaged more in cooperation than in collaboration by dividing the major task that the problem involved into independent subtasks.

Improvements

Problem revision. After this course was over, the instructor wanted to revise the problem details by asking for policy and selection statements instead of lesson plans. She realized that the students already had enough practice with creating lesson plans in previous weeks and that they should pay more attention to the policy part, which was very important in creating a reference inventory.

> I had them come up with lessons for each area. But we'd already done that in the class, so they were just selecting things. And I had a few students who submitted policy and selection statements with their assignments, and those students got higher grades than others because it was a part of the grading rubric to show an understanding of a policy. I didn't make it explicit though… Now I think I would be probably more inclined to

ask for those documents than for the lessons because I think that will be more useful and more variety in the things they do in the class (December 14, 2005).

Synchronous communication. The two students who were interviewed did not have specific suggestions for improving the problem-based learning in this course. They were satisfied with their learning experience through PBL in this course. One student simply mentioned that having a chat room would have been great and that "visual chat would be even better" (December 14, 2005).

Summary

This chapter has described how collaborative PBL was implemented in the second case, "Introduction to Reference" course, presented the strengths and weaknesses of collaborative PBL in the course, and addressed how collaborative PBL in the course could be improved. The strengths, weaknesses, and improvements of PBL in the second case are summarized in Table 5.

Table 5. Strengths, Weaknesses, and Improvements of Collaborative PBL in the Inventory Assignment

Strengths	Weaknesses	Improvements
• The problem was very relevant to the students' careers. • The information environment enabled the students to gain prerequisite knowledge.	• The students engaged more in cooperation than in collaboration.	• Problem revision • Synchronous communication

CHAPTER VI.

CASE 3: PBL IN "ADVANCED PROBLEMS IN LIBRARIANSHIP: COLEECTION DEVELOPMENT"

This chapter presents the results from analyses of both descriptive and evaluative data collected from the third case, a graduate course in the Library and Information Science field. The findings are organized around the following research question and sub questions:

What guidelines are useful for designing and implementing collaborative PBL in an online environment?

- How is collaborative PBL implemented in an online environment? How does the instructor structure and facilitate collaborative PBL?
- What strategies work or do not work under what conditions? What are the strengths and weaknesses of collaborative PBL?
- How can collaborative PBL be improved?

To begin, general information about the case is provided. Second, how collaborative PBL was implemented in the course is described. Third, the strengths and weaknesses of collaborative PBL in the course are presented. Lastly, how collaborative PBL in the course could be improved is addressed.

Case Description

"Advanced Problems in Librarianship: Collection Development" was a three-credit graduate course offered by the online education program in the Graduate School of Library and Information Science at the University of Illinois at Urbana-Champaign (see Table 6). This course examined issues affecting collection development and management for libraries,

including collection development policies, budgeting, collection assessment, multi-media formats, legal issues, collaboration and cooperation.

The instructor of this course was very experienced with PBL as well as with online courses. She had taught seven online courses, including this one, and had used PBL in all of them. She had 26 students in this course. According to her, the students were highly motivated, bright, and over-achieving, and most of them had a full-time job (December 14, 2005).

The course management system used in this course was one developed and owned by the Graduate School of Library and Information Science. It had a simple structure with only four tabs: Syllabus, Archive, Bulletin Board, and Live. Both the instructor and students liked the system very much.

There were five assignments in this course: (1) evolving maps of collection development, (2) collection development policy, (3) six debates, (4) consortium evaluation of virtual information systems, and (5) portfolio. Collaborative problem-based learning (PBL) was used for the fourth assignment, consortium evaluation of virtual information systems.

Table 6. Contextual Information for Case 3

Case 3: Advanced Problems in Librarianship: Collection Development	
Level of learning	Graduate
Learning content	Issues affecting collection development and management for libraries
Course management system	A system developed and owned by the Graduate School of Library and Information Science
Use of PBL	PBL was used for one of five assignments, consortium evaluation of virtual information systems.
Amount of PBL	The second half of the semester
Number of students	26
Amount of experience instructor had with online PBL	The instructor had taught seven online PBL courses.

Implementation of PBL in the Consortium Evaluation Part of the Course

Problem presentation. The instructor presented the problem in the first week. The problem was to form a consortium of libraries, analyze and evaluate library-related virtual information systems by comparing and contrasting various vendors, make a decision on what to purchase and how to pay for it, and write its report together. This problem required the students to play two roles: a member of a consortium and a representative of a library. The students had a responsibility to make the consortium a success collaboratively, and at the same time, they had to meet the needs of their library (Instructor, December 14, 2005).

Although the problem was presented in the beginning of the course, the students were expected to work on the problem throughout the second half of the semester. The course syllabus informed that the problem required contacting experts, such as vendors, aggregators, and publishers, in order to solve the problem. It also informed that the problem would be discussed in more detail at the on-campus session on October 9.

Synchronous sessions. This course held a synchronous session every Tuesday from 4:30 p.m. to 6:30 p.m. The official class meeting time was set up by the online education program by which this course was offered. Usually the synchronous session provided a live lecture for the first hour, and the second hour was discussion-based. Only the instructor could speak, and the students communicated with the instructor and with each other through text-based chat. Four out of 15 synchronous sessions invited a guest speaker, who was an expert on the week's topic. After a lecture, approximately a half hour was given for group discussions. The students discussed questions given by the instructor in their group chat room. Each group had a leader and a recorder. The recorder of each group reported to the class in the last half hour of the session. One staff joined the synchronous session all the time, and she helped the students

whenever they had some technical problems. Throughout the semester, the class covered various topics regarding collection development through the synchronous sessions. However many of them were not directly related to the problem.

Group formation. The Graduate School of Library Information Science required its online courses to have an on-campus session, and this course held it on Sunday in Week 7, which was October 9, 2005. The instructor used this on-campus session to form groups and discuss the problem in detail.

The instructor believed that students are much more engaged when they work on what they are interested in (December 14, 2005), and she helped the students join groups based on their interests. Five different subjects were suggested by those who had a strong interest in them, and groups were formed around those subjects: Chat Reference, Digital Collections, Primary Sources, Reader's Advisory, and Digital Audiobooks. Each group had four to six people. Some of these groups were formed ahead of time and were already working on the problem before the on-campus session.

After the groups were formed, the instructor broke the students into their groups and let them begin to discuss the problem. According to the instructor (December 14, 2005), they talked about what they were going to do and who was going to do what at that stage. The instructor tried to take care of the initial concerns of the students by walking around the room and asking each group if they had any questions.

When asked how differently she would form groups and discuss the problem without the on-campus session, the instructor said that she would have one or more chat sessions so she could talk about the problem and groups with students synchronously. However, she preferred

having the on-campus session because she believed that it would be very complex and time-consuming to form groups online (December 14, 2005).

Collaborative problem solving through diverse communication media. The instructor provided a private bulletin board to each group because the students preferred to have a private work space (December 14, 2005). She also made chat rooms available for group meetings and allowed the groups to use any communication media available, depending on their preferences and needs.

Only two groups, the Digital Audiobooks and Primary Source groups, were willing to participate in this research study. The Digital Audiobooks group with five people started working on the problem before the on-campus session. Their asynchronous discussion in their bulletin board began on September 25, and their discussion revealed that they were planning for their problem solving even before September 25 via emails. In the beginning, Rachel suggested a 13-step problem solving process, and all other members agreed. Although their actual problem-solving process was more complex than the 13-step process, it helped them make considerable progress even before other groups were formed. One member contributed to the group a great deal by providing a lot of background information and resources and identifying relevant consortia and experts. Based on her work, the group divided its tasks, set timelines, searched for and shared more information and resources, interviewed experts, and engaged in many discussions for evaluation of products and for decision making. They met in their chat room twice to make decisions.

> … There were sort of two levels of tasks. The first level was developing library profiles. So which library we're going to represent and what would the library look like… The second level of the task had to do with the vendors. And so we decided that

> we each take a vendor and the other person would do expert commentary. We did interview some experts, trying to give each person some research and interviewing, either product or expert. And then one of our members had web-design expertise, and so she volunteered to create the website. And two of us had presentation experience. We had done a lot of training, and so we just volunteered to do the presentation (Madison, December 19, 2005).

By dividing tasks in a way that all members of the group worked on all components of the problem together, the Digital Audiobooks group engaged in intensive collaboration throughout the problem-solving process.

The Primary Source group had six members. They divided tasks at the on-campus session. Chloe and Jennifer were responsible for vendor interviews, Erica and Ethan for writing up the report, Molly for presentation, and Ashley for developing presentation materials. By dividing the task into independent subtasks, they attempted to individually work on their own part and assemble parts later on. According to Jennifer, they thought their individual tasks were all they needed to do at the beginning. However, they soon realized that it required more than that, and they made adjustments (December 18, 2005). They began posting in their private bulletin board on October 12. They first shared some background resources and their individual library descriptions, and next they made suggestions for potential products and talked about timelines. Then they engaged in evaluation of selected products while contacting vendors, and sometimes had chat meetings after the synchronous session to make group decisions.

In terms of communication media, both the Audiobooks and Primary Sources groups mainly worked in their private bulletin boards. However, they had chat meetings when they needed to make group decisions. When they wanted to make plans or decisions individually

with another member who had a common task, they chose to communicate via phone. The students perceived that synchronous communication was more effective and efficient than asynchronous communication for decision making.

> We used it [chat room] when we needed to make a group decision like when we had to decide which vendor we're going to select… (Madison, December 19, 2005).
>
> We had a chat for two hours at one point. And it can be good because everybody shows up, and you can make a decision. It's easier to make a decision… (Rachel, December 15, 2005).
>
> … Chloe and I talked a lot on the phone because the two of us were doing the vendor contact. And so we talked about what our timetable was and how we're gonna divide it up. Rather than going back and forth with email, it's easier to talk on the phone… (Jennifer, December 18, 2005).

They used email and phone when they contacted and interviewed experts. When they wanted to ask a question to the instructor, they used email, phone, or the "Questions before Class" board. They used FTP or email to share documents because their bulletin board did not allow for attachments.

No structure. The instructor monitored the groups' private bulletin boards at least once a week to check their progress, but she did not make a post. She did not provide any structure in the problem solving process. She expected the students to develop needed structure on their own. She wanted to make the problem solving situation more authentic by having the students deal with the problem without her involvement. Instead, she encouraged the students to contact her if they had questions or needed any help.

> I try not to insert myself into it a lot because I think that most learning comes from them working with one another. They're not going to have somebody hovering over them when they have to form a consortium in the real world. I don't want to do that. I don't hover. I think that that gives them a better sense of trying to deal with the project because libraries are so cooperative that everyone of them is going to have to work in a consortium to do something at sometime in their lives as a librarian. That's the reason I do the project and that's the reason I try not to direct it too much myself because I think they need to have experience working out the problem themselves (December 14, 2005).

Presentations. On December 6 when the final report was due, the five groups made presentations in the synchronous session. Each group had one or two presenters, and the presenters could speak. Twenty minutes were given to each group. During presentations, the students looked at the website of the group presenting, listened to the presentation, and sometimes asked questions to the group. The group members who were not presenting answered questions. After the presentation of each group, the instructor and students made comments. However there was not much dialogue, probably because of the time constraints. Such comments as "very interesting," "good job," and "great presentation" were frequently posted.

Process and peer evaluation. After finishing their problem solving and presentation, the students were required to write a confidential memo to their library director, who was the instructor. According the instructor, the confidential memo had two purposes: simulation of a real-world task and evaluation of the collaborative problem-solving process.

> It's a simulation of what they're going to have to do one day when they get out into the real world. Whenever I go as a librarian to a consortia meeting and we make a

> decision, I have to come back and write a note to my dean telling him what I think of the process and what I think we should do, and that's what this is about. This is to give them the experience in doing that. It's also an opportunity for them to give me feedback on the process. And so I use it for both those things (December 14, 2005).

The students were asked to include their evaluation of their collaborative problem solving process and peers with a letter grade for each of their group members in the memo.

Instructor assessment and feedback. By having the students evaluate their collaborative problem solving process themselves, the instructor focused on the quality of the final reports in her assessment. She determined the grades of individual students by averaging her grade and the highest grades given by peers.

> I look at the report, and I'm kind of strict about the report because when they get out into the real world, they have to do a report for a consortium project. They're going to have to send it to the directors of all their schools… So I do make comments on them. My grade is more of a content grade and theirs is more of a process grade. And what I do is I drop the lowest one (December 14, 2005).

Overall the instructor was very impressed and pleased with the students' performance in this class. She did not talk about the students without compliments.

> They all did a real good job. They did an amazing job… These students are highly motivated, and they are very bright… They are dream students. They really are. They are wonderful (December 14, 2005).

The instructor posted her feedback on the final reports to the private group discussion boards. Her feedback for each group had approximately 200 words. In her feedback, she discussed what and how they did well, pointed out what they did not consider, addressed an alternative solution,

and explained relevant issues.

Strengths

Provided more learning opportunities through synchronous sessions. This course examined a variety of practical issues and problems regarding collection development through the weekly synchronous sessions. By providing live lectures and engaging the students in discussions every week throughout the semester, the instructor helped them think about many issues that were not directly related to their problem solving as well as relevant issues. The students could learn more than what the problem required them to learn through the synchronous sessions.

Allowed students to select the problem context based on their interests. The instructor allowed the students to choose the virtual information system they were going to evaluate. It enabled them to explore what they were interested in and also gave them opportunity to learn about other products selected by other groups. Although there was no inter-group collaboration, the students could learn about other products and different approaches for making a decision collaboratively in a consortium when they looked at other groups' reports and listened to their presentations at the end.

Enabled students to communicate both asynchronously and synchronously. The instructor respected each group's communication style or preference and made diverse communication media available. The students could communicate both asynchronously and synchronously through their private bulletin board, chat room, email, and phone, depending on their group's needs and preference. The students in the two groups participating in this study mainly worked in their private bulletin board, but they met in their chat room or talked on the

phone, especially when they needed to make a decision. They perceived that synchronous communication was more effective and efficient than asynchronous communication for decision making. Having ways to communicate both asynchronously and synchronously seemed to make their problem solving more effective and efficient.

Considered both process and product of PBL in assessment. Since this class was very large with 26 students, it was difficult for the instructor to evaluate the problem-solving process and individuals' contributions as the instructor in the first case did. However, the instructor helped the students pay attention to their collaborative problem-solving process as well as their report by having them write a confidential memo that included their evaluation of their group process and peers and a grade for each group member.

Student Perceptions of Weaknesses

There was insufficient communication between instructor and students. The instructor let the students solve the problem on their own without any structure and guidance from her and had them take initiative to talk with her if they needed any help or had a question. The approach worked in this class, making the problem solving more authentic, because the students were in general highly motivated and very active in their learning and problem solving. Some students asked questions and asked for help when they had difficulty finding resources or experts. However, the student interviews revealed that some students had problems with communicating with the instructor about the consortium project. The Audiobooks group did not have any communication with the instructor because their group somehow formed a kind of group norm that they should not ask the instructor for help.

> Once we had the assignment, we really didn't have any more contact with her about the assignment (Madison, December 19, 2005).
>
> Our group never communicated with the instructor about the project. I think one time when I asked a question, I got into trouble with people in my group. They were really mad because I asked the question, which I thought really silly... It was up to us to talk to her, but our group was very sort of co-dependent on each other… Nobody wanted to ask, and when I asked, people were mad at me… I think when groups get too sort of into their own group thinking, and they don't wanna ask for instruction or help or anything, then it can be troublesome. Because sometimes there's a thought that we shouldn't ask the instructor for help or guidance or anything, and I think sometimes that can be harmful to a group… (Rachel, December 15, 2005)

It was also found that some students were uncomfortable with asking questions at the synchronous sessions where the instructor encouraged them to ask questions, either because they did not want to talk about their group's problem in front of the entire class, or because they did not want to take class time with their questions.

> If your group was having trouble, you don't wanna say that in front of the whole class (Rachel, December 15, 2005).
>
> It would take class time. It was always difficult because there's a lot to cover in the class (Madison, December 19, 2005).

Improvements

The instructor was very pleased with the students' performance and did not have specific plans or ideas for revising or improving the collaborative PBL in this course. The student

interviews also revealed the students' satisfaction with the PBL experience. However, there were a few suggestions for improving the problem-solving process.

Meeting with each group. Madison in the Digital Audiobooks group mentioned that it might be helpful if the instructor met with each group once or more through conference call to check their progress, provide feedback, and answer questions.

> I suppose one possibility would be for the instructor to schedule to meet a least once with each group to see how they're doing, answer questions, and offer some feedback… I would wonder if there would be a way that we could build in some conference call… We could schedule two or three of them during the course of the project, and the professor could attend one of those or more by invitation. I do think having conference call might be useful… (Madison, December 19, 2005).

Tailored structure. It appeared that some students needed more structure from the instructor while others were very comfortable with solving the problem on their own without any structure from the instructor**.** Rachel in the same Digital Audiobooks group thought that "it might have been a good idea to have one check-in point or two somewhere along the way" to help them start earlier and get things done earlier, talking about their problems with setting deadlines very late. She also mentioned that it would be helpful if the instructor checked the group bulletin boards to see what's going on and make clear that the students can talk to her.

> I'm gonna pay attention, I'm gonna be reading the board, I wanna know what's going on, if there're problems, talk to me… Just really clarify it is okay to talk to the instructor… I think that helps (Rachel, December 15, 2005).

On the other hand, Jennifer in the Primary Source group believed that there was nothing the instructor could do to better facilitate their problem-solving. She mentioned that, although her group had problems, they got over it.

> In our case, I don't think anything different she could have done. Because her objective of the assignment, as far as I understood, was to have some experience of real collaborative process, and in that situation, it was in our hands (Jennifer, December 18, 2005).

Leader or facilitator. With regard to what they could have done differently, Madison in the Digital Audiobooks group and Jennifer in the Primary Source group thought that it could have been better if they had a leader among themselves.

> Unless you have a designated leader who is really following and facilitating, things get lost very easily… We didn't have a designated leader… I think it could have been better if we had a leader. It helps keep people on task and helps the group move along (Madison, December 19, 2005).
>
> The only thing that might have helped for the group itself is to have picked a leader. And we didn't… In a real-life situation, you might have someone who directs the consortium. We might have picked one among ourselves… (Jennifer, December 18, 2005).

Madison also thought it might be helpful if the instructor required groups to pick a facilitator.

> One thing that the instructor could do is require that there be a facilitator and maybe even meet with the facilitator to talk about their role or see how the group's doing… I don't think that the instructor can do that (play the role of the facilitator) for a couple of reasons. One is, I think it's too time intensive. And two, that puts her in position I

think of having too much input and responsibility into the project. And I think the project really needs to be student-led (Madison, December 19, 2005).

Summary

This chapter has described how collaborative PBL was implemented in the third case, "Advanced Problems in Librarianship: Collection Development" course, presented the strengths and weaknesses of collaborative PBL in the course, and addressed how collaborative PBL in the course could be improved. The strengths, weaknesses, and improvements of PBL in the last case are summarized in Table 7.

Table 7. Strengths, Weaknesses, and Improvements of Collaborative PBL in the Consortium Evaluation Assignment

Strengths	Weaknesses	Improvements
• Provided more learning opportunities through synchronous sessions. • Allowed students to select the problem context based on their interests. • Enabled students to communicate both asynchronously and synchronously. • Considered both process and product of PBL in assessment.	• There was insufficient communication between instructor and students.	• Meeting with each group • Tailored structure • Leader or facilitator

CHAPTER VII.

DISCUSSION AND CONCLUSION

This final chapter first provides guidelines that might be useful for designing and implementing collaborative PBL in online environments (see Figure 1). The guidelines are based on cross-case analyses. Brief contextual information of the three cases is summarized in Table 8 below. This chapter also provides a discussion of the limitations of the study, the directions for future research, and a conclusion.

Table 8. Contextual Information of the Three Cases

	Case 1: Technology: Use and Assessment	Case 2: Introduction to Reference	Case 3: Advanced Problems in Librarianship: Collection Development
Level of learning	Graduate	Graduate	Graduate
Learning content	Technology use and technology assessment	Reference resources for K-12 school libraries	Issues affecting collection development and management for libraries
Course management system	Blackboard	Blackboard	A system developed and owned by the Graduate School of Library and Information Science
Use of PBL	PBL was used for the Technology Assessment part.	PBL was used for one of six assignments, the inventory assignment.	PBL was used for one of five assignments, consortium evaluation of virtual information systems.
Amount of PBL	Six weeks	Two weeks	The second half of the semester
Number of students	Nine	Five	26
Amount of experience instructor had with online PBL	The instructor had taught eight online PBL courses, including this course.	The instructor had used PBL in this course for three years.	The instructor had taught seven online PBL courses.

Guidelines for Online PBL

Consider using PBL for a part of a course.

Some instructors might think that PBL is not an appropriate method for their courses because they cannot think of a good way to cover all learning issues they think are important with one or a series of problems. As a matter of fact, it is difficult and almost impossible to create or find problems that cover all important learning content. However the study results indicate that we do not have to create or find such a problem and can flexibly use PBL for a part of a course. Interestingly, none of the three cases used PBL for the entire course. They all used PBL as one of several assignments. They used other instructional methods, such as lectures, discussions, and individual projects, to teach other parts of the course or support PBL, and it was an effective and efficient way to cover diverse learning content.

PBL is not the best way to teach everything. As Nelson (1999) proposed, collaborative problem solving is effective when learning involves heuristic tasks and developing conceptual understandings and cognitive strategies. Lectures or simple individual reports can be more effective for some learning content that requires simple memorization or comprehension. Therefore, one does not have to try to use PBL for the entire course. Considering the time-consuming nature of PBL and the limited time period of a course, it would be wise to use PBL for a part of a course if other parts of the course can be effectively taught in other ways. Also, it might be necessary to use PBL with other instructional methods when a problem does not cover many important learning issues or when students do not have sufficient requisite knowledge.

Consider not using PBL if logistics of scheduling will make student collaboration difficult.

Online PBL may not be feasible in some situations. For example, if students are literally from all over the world and if most of them are working in full-time jobs, collaboration will be difficult due to incompatible time zones and work schedules. If the problem needs to be solved in a relatively short period time (e.g., a few weeks or months), collaboration will be even more difficult. Therefore, instructors need to consider time zones where students live or work full time and their work schedules when designing online PBL.

Select or create a problem that is relevant to students' current or future careers.

PBL depends on students' self-directed learning, so it is very important to create a problem that is relevant to students in order to get them engaged in learning and problem solving. In the first case, the residential heating technology assessment was an important real-world problem, but it seemed that the problem was not very relevant to the students' careers. The students suggested that the technology assessment activity could be improved if it showed how it could affect them as teachers, how it could be used in their classrooms, and how it could help their students. On the other hand, the problems in the second and third cases were very relevant to the students' current or future careers, and it made them active in their learning and problem solving. Particularly in the last case, the problem left room for the students to choose the problem context based on their interests, and the students were very active and even over achieving. From the findings, we learn that it is important to first learn about what students are interested in and what they need to learn for their current and future careers and to provide a problem that addresses those interests and needs. When possible, it might be useful to involve students in creating a problem or to allow them to select or define problem specifics based on their interests.

Take the number of solutions, the problem context and structure, and the available time into account when creating a problem.

Problems for PBL are typically complex, authentic, and ill-structured. However they can also vary in many ways, as the problems in the three cases evidenced. Some may ask for one best solution, but others may accept several alternatives. Some may provide a specific context for problem solving, but others may allow students to select the problem context based on their interests. Some may provide some structure by specifying information needs or format of the final product, but others may allow for more flexibility in defining, solving, and presenting the problem. Some may need a whole semester to be solved, but others may be solved in a few weeks. Therefore, when creating a problem for collaborative PBL, it is worthwhile to consider the number of solutions, problem context, structure, and time to provide a better PBL environment.

Determine the group size, considering the nature of the problem and communication media.

What would be the optimum size of collaborative problem solving groups in online environments? Uribe and Klein (2003) proposed that grouping students into groups of more than two may not be a good strategy because, as the number of members increases, the confusion from the simultaneous communications become greater, and the positive effect of collaboration on problem solving may decline. Their study results showed that learners who worked in dyads performed significantly better in solving ill-defined problems than those who worked in teams of four.

Would the optimum size of a collaborative group be the same when students use only asynchronous communication media or use both asynchronous and synchronous communication

media? This study suggests that the size can be very different when asynchronous communication media are used. According to the instructors in the three cases, four might be the optimum size for an online collaborative group in general when students mainly communicate asynchronously. When communicating asynchronously, students are often frustrated by no or late responses from their group members. The delay in discussions appeared to be one of the main problems in online problem solving in this study. Therefore, a group in general needs to have enough people to keep the momentum in their dialogue when mainly depending on asynchronous communication. However if the group is too large, it would be harder for students to reach a common understanding of a problem or there might be some students who disappear or lurk. Thus, three to five seems appropriate for online PBL when mainly using asynchronous communication.

Furthermore the size can vary depending on the problem, according to the data from instructor and student interviews. The instructors and several students believed that only a few people could be enough for some problems, but four or five people could be needed for other kinds of problems. Thus, the communication media and the nature of the problem appear to be two important factors to consider when deciding the size of a collaborative group.

Discuss online collaboration before problem solving.

People choose to take an online course mainly because it allows them to work when they can or when they want to. Therefore, most online learners dislike collaborative work, for which they have to depend on others who have different schedules. The students who participated in this study also had negative attitudes toward online collaboration. Online collaboration appeared to be one of the most difficult parts in their collaborative PBL. In order to successfully

implement collaborative PBL in an online environment, the instructor should first deal with students' negative attitudes toward online collaboration. It might be useful to discuss the importance and advantages of collaboration and how to deal with the difficulties that online collaboration might involve before students engage in problem solving.

Ensure that students have sufficient requisite knowledge.

According to the original PBL model developed for medical education, students in a group attempt to define the broad nature of the problem, based on their prior knowledge and experiences, and identify learning issues. They do not receive any instruction before the problem is presented. This original PBL approach may not be a realistic way for all kinds of courses and students. For example, the approach may not work well in a situation where students with little prior knowledge and experience have to solve a highly ill-structured problem within several weeks. The results of this study indicate that collaborative PBL can be more successful when students have sufficient requisite knowledge. In the first case, the students did not have sufficient requisite knowledge, were overwhelmed by the information made available, did not pay enough attention to important issues, and could not produce quality technology assessment reports. On the other hand, the students in the second case acquired background knowledge through the information environment, and they could solve their problem successfully without much confusion and struggle. Thus, it is important to figure out whether students have requisite knowledge or not before providing a problem. If students lack requisite knowledge, it might be wise to expose them to basic information and resources so that they can gain sufficient requisite knowledge and focus more on creative or higher-level aspects of problem solving.

Assign a considerable portion of the grade to learning and problem-solving processes.

Assessment drives and shapes student learning, since students focus on what is assessed. If the instructor assesses only final reports, for example, the students are likely to focus on their report, paying little attention to their discussions and collaborative learning as seen in the second case. On the other hand, if the instructor assesses the quality of discussions as well as the solutions as the instructor in the first case did, students pay more attention to their problem-solving process. Therefore, it is important to involve both product and process aspects of PBL in assessment. It might be an effective way to assign a considerable portion of the grade for PBL to learning and problem-solving processes.

Provide both synchronous and asynchronous communication media.

Solving a complex and ill-structured problem in a group involves a lot of decision making and requires great interdependence with others. Several studies suggest that face-to-face communication is more effective than computer-mediated communication for interdependent tasks because people can more easily reach a consensus using immediate verbal and non-verbal feedback (Archee, 1993; DeSanctis & Monge, 1999; Straus & McGrath, 1994). In a similar vein, the data from the first and third cases suggest that synchronous communication can be more effective and efficient than asynchronous communication for decision making. Asynchronous discussions give students more time to think about the content and enable them to post thoughtful messages (Althaus, 1996). In addition, asynchronous communication allows students to work at their convenient times. At the same time, students often waste lots of time just waiting for responses from group members and get frustrated when they try to reach a consensus through asynchronous discussions. Therefore, it is important to make both synchronous and

asynchronous communication media available and to enable students to choose appropriate media depending on their needs.

Help students divide tasks properly so that they can collaborate rather than cooperate.

In collaborative PBL, instructors hope that students will learn from group collaboration by testing their own ideas and perceptions against alternative views of others and expanding their understanding and perspectives. The results of this study, however, indicate that students tend to cooperate rather than collaborate by dividing tasks into independent subtasks as much as possible. Collaboration and cooperation are often used interchangeably as synonyms. However, it is important to be aware of their differences in order to engage students in collaborative learning.

According to Dillenbourg, Baker, Blaye, and O'Malley (1995), both collaboration and cooperation involve task division. However, they differ in terms of how the task is divided. In cooperation, a task is hierarchically divided into independent subtasks, each person is responsible for a part of the task, and coordination is only required when assembling parts. On the other hand, in collaboration, cognitive processes are heterarchically split into intertwined layers, people need to work on all components of the task together constructing a shared understanding, and therefore coordination is required throughout the process. Collaborative PBL is meaningful only when students benefit from collaborative learning. In order to maximize learning from collaboration, instructors should ensure that students divide tasks properly so that they can collaborate rather than cooperate.

Provide tailored and flexible structure.

Previous research suggests that a fairly strict structure for the problem-solving process is critical for successful implementation of online PBL (Dennen, 2000; Orrill, 2002; Steinkuehler et al., 2002). However the results of this study suggest that individual students have different needs for structure and that a rigid structure for the problem solving process is unnecessary, especially for highly motivated or advanced students. If instructors define and structure the problem-solving process and have students go through the safe steps, they will probably solve the problem more efficiently without much trial and error. However, it would be hard for them to gain valuable problem-solving strategies that can be learned when they make an action plan based on their knowledge and experience, revise their plans, and manage unexpected problems. If we focus only on the final product, a strict structure can be a good way to help students produce a high quality product. However, the focus of PBL should be more on the problem-solving process rather than on the end product. Learning through collaborative inquiry in a real-world context should not be sacrificed for a desirable solution. Therefore, as the instructors in the three cases contended, it is important to have students determine an appropriate problem-solving process on their own. However, as seen in the first and last cases, some students need more structure from the instructor while others are comfortable with solving a problem on their own without much structure from the instructor**.** Therefore, for students who need more structure or guidance, it would be desirable to provide tailored and flexible structure when needed.

Provide tailored instruction or cognitive scaffolding when appropriate.

The results of this study suggest that groups can have different learning needs based on their interests and problem solving plans. The three groups in the first case had very different

learning needs, even though they were working on the same problem. Therefore, an instructor needs to carefully monitor each group and consider providing tailored instruction when appropriate. Just-in-time instruction can solve many problems and facilitate learning and problem-solving. However, as long as students are not missing critical learning issues, it might be better to facilitate their learning and problem solving by providing cognitive scaffolding, rather than by providing direct instruction. Asking thought-provoking questions, raising issues, and modeling critical thinking can help students be critical, broaden their perspective, and engage in meaningful discussions. When a class is too large, however, it is hard for the instructor to carefully monitor each group and individuals and provide tailored instruction or scaffolding. In such a case, it is important for the instructor to take initiative to communicate with each group once in a while in order to provide needed support.

Provide opportunities for learning after problem solving.

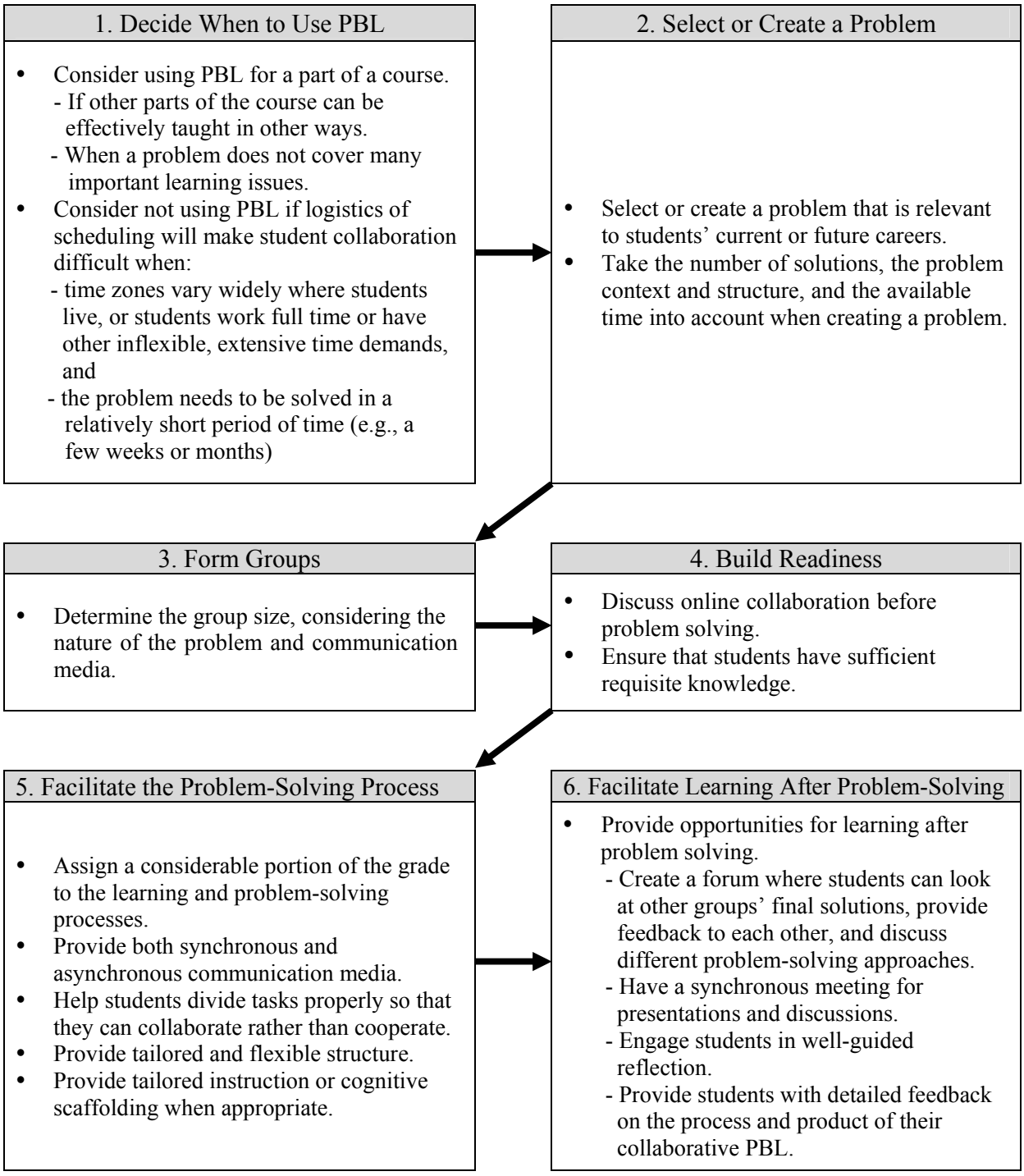
Although learning during problem solving is critical, learning after problem solving is also highly important. The findings of this study suggest several ways for facilitating learning after problem solving. First, the instructor can create a forum where students can look at other groups' final solutions, get new insights from comparing and contrasting different solutions, provide feedback to each other, and discuss different problem-solving approaches. If it is possible for the whole class to meet synchronously, the class can have a synchronous meeting for presentations and discussions.

Second, the instructor can engage students in reflection. Well-guided reflection can help students make their tacit knowledge gained through collaborative PBL more explicit, so it can be easily used in the future problem solving. Without appropriate guidelines for reflection, students

tend to discuss what they have learned only in terms of content. In order to help students benefit from reflection, it is important to have them reflect on their individual learning and collaborative problem-solving processes. It might be useful to have them think about what kinds of learning and problem-solving strategies were effective or ineffective, how differently they could have solved the problem, and how differently they would approach similar problems they might face in the future.

Finally, the instructor can help students learn a great deal after problem solving by providing detailed feedback on the process and product of their collaborative PBL. Beyond pointing out strengths and weaknesses of the final solutions, the instructor can discuss other alternatives and missed learning issues.

Figure 1. Guidelines for Online Collaborative PBL



Limitations and Future Research

This study suggests a number of practical guidelines for designing and implementing collaborative PBL in online environments. However, those guidelines are based on findings from only three graduate-level courses in the technology and library science fields. Therefore, they might not be appropriate for undergraduate-level courses or for other disciplines. In addition, PBL was used for only a part of a course in all three cases. There might be limitations in applying the guidelines to PBL that is used for an entire course or for a whole program. One should also note that two of the cases had an on-campus session at the beginning of the PBL. Although the students did not spend much time together as a group at the on-campus session, it might have affected their online problem solving later on.

Further studies might explore diverse online PBL courses in different subject areas or disciplines, as well as at different levels of learning, in order to revise and refine the guidelines proposed in this study. Second, future studies could examine whether or not instructional methods presented in the individual cases work in other conditions. For example, researchers might explore the effect of cognitive roles on collaborative problem solving. Third, it might be interesting to explore online PBL courses where synchronous discussions are more dominant. Finally, future research could explore new technologies for online PBL. In the future when more advanced technologies are available, we might need to develop different kinds of guidelines for online PBL.

Conclusion

This study examined three graduate-level online courses that utilized collaborative PBL, considering each course as a case. Beyond describing what happened in each case, this study

identified what worked and did not work in the collaborative PBL and explored how the collaborative PBL could be improved by collecting both descriptive and evaluative data.

A series of guidelines has been proposed based on syntheses and analyses of descriptive and evaluative data collected in the three cases. They provide practical tips for diverse stages of the design and implementation of collaborative PBL in online environments. Researchers are encouraged to test the guidelines in diverse situations to revise and refine them and to develop a more comprehensive and practical knowledge base to guide practitioners, such as instructional designers and instructors, who design online PBL courses or use the PBL approach in online courses.

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PROFESSIONAL EXPERIENCE

- Web Designer, Paul Munger Conference, IUB, October 2005 – January 2006
- Graduate Assistant of Web Director of School of Education, IUB, July 2003 - June 2005
- Volunteer Teaching Assistant, Instructional Systems Technology, IUB, Fall 2004
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- Instructional Designer / e-Learning Specialist, Hana Bank, November 2002 - May 2003
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- Volunteer Teaching Assistant, Instructional Systems Technology, IUB, Spring 2002
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- WBI (Web-based instruction) Designer/ Project manager, Instructional Systems Technology, IUB, October 2001 - June 2002
- Member, Research team on a project to facilitate systemic change in a small school district in Indianapolis, September 2001 - August 2002
- Multimedia Developer, IT Training & Education, UITS (University Information Technology Services), Indiana University, May 2001 - August 2001
- Student Teacher, Do-Gok Middle School, South Korea, Spring 1999
- Private Tutor, South Korea, 1996-2000

PUBLICATIONS

- Reigeluth, C. M., & An, Y. J. (2006). Functional contextualism: An ideal framework for theory in IDT. *Educational Technology Research and Development, 54*(1), 49-53.
- An, Y. J., & Frick, T. (2006). Student perceptions of asynchronous computer-mediated communication in face-to-face courses. *Journal of Computer-Mediated Communication, 11*(2), article 5.
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- Frick, T., Su, B. & An, Y. J. (2005). Building a large, successful Website efficiently through inquiry-based design and content management tools. *TechTrends, 49*(4), 20-31.

PROFESSIONAL CONFERENCE PRESENTATIONS

- An, Y. J., & Frick, T. (2004, October). *Blended instruction: Student perceptions of communications technology in face-to-face courses.* Annual meeting of the Association for Educational Communications and Technology, Chicago, IL.
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AWARDS & HONORS

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SERVICE

- Manuscript reviewer, Asia Pacific Education Review (APER), Education Research Institute, Seoul National University, April 2006
- Discussant, International and U.S. University Curricula in Educational Communications and Technology, Association for Educational Communications and Technology International Convention, Orlando, FL, October 2005
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