Learning to Solve Complex Problems Through Between-Group Collaboration in Project-Based Online Courses

Yiping Lou*
Louisiana State University, Baton Rouge, USA

Online courses have been criticized for their focus on knowledge acquisition rather than on how to solve authentic complex problems, a skill that is increasingly being recognized as critical to meeting the challenges in the real world. The purpose of this study was to explore whether between-group collaboration in project-based online courses can promote student learning of complex problem solving. Eleven graduate students in an educational technology class participated in this study. Each group of three to four members designed and developed a 2-week online mini-course that was later implemented with classmates across groups. During the semester, students were encouraged to visit other group areas, discuss challenges, and share strategies in the online course environment. The results indicate that between-group collaboration was effective in improving group processes, group project performance, individual student achievement, and confidence in complex problem solving in designing online courses.

Introduction

As information and communication technologies become more prevalent, an increasing number of courses are being offered online, in order to meet students’ needs and their demand for flexibility. At the same time, many researchers and educators have expressed concerns regarding the quality of these courses. One of the major concerns with online courses is that many of them focus on a traditional knowledge acquisition model of learning rather than on engaging students in solving complex real-world problems (Clark, 2003; Gutierez, 2000; Jonassen, 2002; Marra & Jonassen, 2001; Morley, 2000). One recent university survey of faculty and student use of Blackboard™ found that 77% of the students reported printing and reviewing course documents as their primary usage, and 8% reported participating in the discussion board and taking quizzes as their primary usage (Ansorge & Bendus, 2003).

*Department of Educational Leadership, Research and Counseling, 111 Peabody Hall, Louisiana State University, Baton Rouge, LA 70803, USA. Email: ylou@lsu.edu

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Kanuka (2002) interviewed 12 university instructors who had experience in teaching Web-based distance education courses. The interview data revealed that the instructors were aware of the different characteristics of online versus traditional classroom instruction and of the importance of facilitating online discussion. No mention, however, was made about incorporating complex problem-solving activities in the online courses.

**Situated and Social Cognition**

The traditional knowledge acquisition model of learning has long been criticized for producing inert knowledge in the students, who are often unable to apply that knowledge in solving complex real-world problems. According to theories of situated cognition and constructivist views of learning (e.g., Brown, Collins, & Duguid, 1989), knowledge is embedded in and inseparable from the context in which it is acquired. What contributes to effective knowledge construction is not rote memorization but engaging in the process of problem solving (Jonassen, Howland, Moore, & Marra, 2003). The literature on social cognition and distributed cognition (e.g., Salomon, 1993) suggests that knowledge is socially constructed through interaction with others and with the context. An effective way of learning, therefore, is to engage learners in the collaborative problem solving of real-world problems (Nelson, 1997).

**Problem Solving**

Problem solving may have been examined in different ways by different researchers, but these representations share several common features (Aspy, Aspy, & Quimby, 1993; Vernon & Blake, 1993). Four of the critical features are: (a) a problem is an unknown value, process, method, etc; (b) the unknown is worth finding and requires the mental representation of some situation in the world; (c) a representation of the problem may be produced individually or collaboratively; and (d) solving the problem requires some mental manipulation of the problem space, such as model building, hypothesis generation, speculation, solution testing, information gathering, etc. (Jonassen, 2002).

Problems may be well-structured or ill-structured, ranging from more structured puzzles, algorithms, and story problems to less structured troubleshooting, design problems, and dilemmas (Jonassen, 2000). Unlike the problems found in most textbooks that are well-structured and have only one correct answer, problems in the real world are often ill-structured, and finding their solutions depends on a large number of ever-changing and interrelated variables such as goals, contexts, content, obstacles, and unknowns (Reich, 1990). Learning to solve complex ill-structured real-world problems requires that the students not only learn discrete declarative knowledge but also dynamic procedural knowledge, and cognitive flexibility, which demands considerable context-specific problem-solving practices (Van Merrienboer, 1997).
Learning to Solve Complex Problems in Online Courses

Jonassen (2002) argues that the focus on "reproductive learning" in online courses resulted from the design limitations of the current popular course management systems. These systems present courses in ways that resemble traditional face-to-face instruction with the functionality to deliver lectures, readings, synchronous and asynchronous communication, and quizzes only. Jonassen described two technological approaches to designing online problem-solving environments. One approach was designing problem-specific environments. An example that Jonassen described was a constructivist learning environment for aggregate planning in an accounting firm, which consisted of problem contexts (e.g., demand, technology, sales, human resources, and inventory), cognitive tools (e.g., spreadsheets), and tools for collaborating (e.g., discussion boards and chat rooms) (Jonassen, 1999).

A second more scalable approach described by Jonassen (2002) was designing type-specific problem-solving architectures such as a troubleshooting architecture. According to Jonassen (2002), a troubleshooting architecture should consist of a library of troubleshooting cases with step-by-step procedures that a learner could consult for similar cases, and a troubleshooter that a learner could use to design troubleshooting actions, enter a hypothesis, get results, and enter an interpretation. Both approaches aim to provide technology-mediated scaffolding functionalities and resources that would guide learners in the process of problem solving. Although the second approach promises more economy of scale, designing such an architecture requires technical expertise that many online educators may not have.

Several researchers have investigated the effects of small group project-based learning (PBL) in helping students develop integrative higher order learning and complex problem-solving skills in online courses. PBL is a constructivist-based approach that engages students in solving real world problems (Barron, 1998; Blumenfeld et al., 1991). In PBL, students often work in a three- to five-member team to select a project topic, define project focus and hypothesis, design procedures to test hypotheses, implement the procedures, and evaluate the results. PBL is student centered. It requires the students to be self-directed in their learning, to be able to work in groups, and to apply content knowledge and skills in solving real-world problems. Wang, Pool, Harris, and Wangemann (2001) describe a Motorola Expeditions project where teams of teenagers worked together to solve a real-world problem, designing marketing plans for personal communication technologies. In Thomas and MacGregor (2001), teams of three to four undergraduate students in an educational technology class collaborated online asynchronously or synchronously as they designed team instructional Web sites.

A common problem that is found with small group PBL is that some teams work effectively and some do not (MacGregor & Lou, 2003). Because there is little or no communication between groups, the lessons or strategies used by one group are seldom learned by other groups. Furthermore, in courses in
fields of study such as instructional design where a variety of project experiences are desired, each group gets only one limited snapshot of a project problem and one solution. One way in which it may be possible to help groups learn from each other is through between-group collaboration.

Communities of Practice and Between-Group Collaboration

"Communities of practice" is often defined as groups of professionals with similar goals and interests, who in the execution of "real work" share similar problems and beliefs, and have the real need to share expertise (Wenger, 1997). Communities of practice are being increasingly recognized as an invigorating source of growth for successful organizations or professions in today's knowledge era (Lesser & Storck, 2001). Success stories include: Xerox, National Semiconductor, and the Federal Highway Administration Department of Transportation (Burk, 2003). This approach is also being embraced by online educators as a way for members to share expertise and ideas, and to build collective knowledge (Harrison, 2002). Communities of practice differ from group projects in that members of a community of practice often do not work on the same project team. This has important implications for designing between-group PBL in online courses. By encouraging teams to exchange ideas and share experiences while working on different projects, the learners can develop skills in solving a wider variety of authentic complex problems.

De Simone, Lou, and Schmid (2001) conducted a study on meaningful learning in an undergraduate educational psychology distance education class that used open access group forums on FirstClass™. They found that although each group was assigned a separate group area for the discussion of course topics and ideas, students not only communicated within their own groups but also visited other groups to see how other groups were doing, to ask questions, and to share learning strategies.

Lou, Dedic, and Rosenfield (2003) explored between-group collaboration in classroom-based educational technology courses that were supplemented with online small group learning. To help project groups learn from each other, each group was required to evaluate a partner group's design product and provide constructive peer feedback in online discussion forums. Students perceived the experience of both receiving and providing feedback as beneficial to their learning because it helped them see the strengths and limitations of other projects as well as their own.

The purpose of this study was to explore further how between-group collaborative learning strategies could be employed to foster complex problem solving in project-based online classes. Specifically, this study explored the following research questions: (1) does between-group collaboration enhance student learning of complex problem solving in project-based online courses? (2) In what ways does online between-group collaboration contribute to student learning of complex problem solving?
Method

Research Design and Participants

This study was designed as a mixed-method case study (Tashakkori & Teddlie, 2003) that used both quantitative and qualitative data. The participants were 11 students taking a graduate-level educational technology course. Nine were female and two were male. The majority of the students were majoring in educational technology; a few students were majoring in other areas such as adult education. Three of the students had taken other online courses before this class. The instructor had taught the same course in the previous year using PBL without employing between-group collaboration strategies.

Course Context and Design

The primary goal of the course was learning how to design online courses. Designing online courses is a complex problem that requires taking a variety of interrelated factors that are associated with teaching and learning in the online environment into account. These factors include: the characteristics of the learners, the instructor, the learning content, instructional goals, and the characteristics of the technology. The course was conducted primarily online with only two face-to-face class meetings: one in the second week for course orientation and team building, and the other as part of the final examination. The reason for online delivery was for all students to have first-hand experience of being a student in an online course. Apart from weekly readings and online discussions, students engaged in a major project. This project required them to work in collaborative teams to design and develop an online course. In the previous year of the course offering, each team worked on any topic of its choice. Because of the lack of implementation opportunity, the students finished the course without knowing how the target learners would actually react to the courses that had been designed and without experiencing any implementation challenges or trying out strategies for meeting the challenges during implementation. In the current year, the course was redesigned to include two between-group collaboration strategies: (a) between-group project implementation; and (b) between-group observation of group project processes.

Between-Group Project Implementation

In order for students to experience the whole process of online course design and implementation in an authentic context, each team used members of the other teams as their target learners. In the face-to-face orientation session, students were randomly assigned to groups of three to four members. Each group brainstormed several topics for a 2-week online mini-course that they would be capable of designing and other classmates would be interested in taking. They then constructed and administered a needs assessment survey to
determine which topic would best meet the needs and interests of their classmates. During the design process, each team was encouraged to conduct some formative evaluation with its target learners through the online class discussion board. To simulate real online course design and teaching, each team was provided with a separate Blackboard™ course site in which to design its mini-course. The implementation of the mini-courses took place during the last 2 weeks of the semester.

Between-Group Observation of Group Project Processes

For the first half of the semester, each group collaborated on its project in its own closed group area on the Blackboard™ course management system online. At mid-semester, all students were provided access to all group areas. Each student was encouraged to visit other group areas, observing and analyzing the project processes through reading the online collaborative discourse and taking note of the challenges encountered and the strategies employed in each project, and then sharing the observations in the class discussion forums. The purpose of this strategy was two-fold: (a) to experience a variety of complex problem solving in online course design; and (b) to use the online discourse of other groups and their own group as authentic case studies of challenges met and strategies used in online learning.

Data Collection and Analysis

To answer the research questions, both qualitative and quantitative data were collected over the duration of a semester. The qualitative data included online dialogues, journal entries, and project performance. The quantitative data included individual achievement tests and responses to an attitude questionnaire.

Qualitative data. Online dialogues and journal entries were examined through content analysis for aspects of complex problem solving in online course design and implementation. These included: identification of key issues and challenges; discussion of alternative strategies to meet the challenges; and implementation and evaluation of the strategies used. Project performance was evaluated on evidence of complex problem solving through analysis of group collaboration dialogues, comparison of the first and final versions of the mini-course designs, observation of the course implementation, and assessment of the revisions made based on the course implementation.

Quantitative data. Individual achievement on complex problem solving in online course design was assessed using a pretest and posttest design. The pretest was administered at mid-semester before between-group collaboration activities were implemented. Each student was asked to write an essay describing how they would assist a professor in adapting an existing face-to-face
course that they had taken recently for online delivery. The required elements included: a description of the existing face-to-face version of the course (including course goals and instructional strategies), the rationale for the redesign, the challenges expected, and the instructional strategies recommended. The maximum score for each of the four components was 25% of the total test score, which was 100. The posttest was administered as part of the final examination at the end of the semester. In the posttest, the students were asked to redesign a face-to-face academic course or professional development that they had taken or taught for online delivery and present it at a poster session at the end of the semester. The required basic elements were the same as in the pretest. The difference between the pretest and posttest was evaluated using a paired-sample $t$ test at the 0.05 significance level.

Data on student perceptions were collected through an attitude questionnaire designed to elicit student reactions to the between-group collaboration. The instrument consisted of 29 items: 1 item on student general preference for group or individual projects, 5 items on within-group learning experiences, 9 items on perceived cognitive and motivational benefits of between-group collaboration, 5 items on within- and between-group collaboration, and 9 items about the course in general. For each item, students were asked to rate their responses on a 5-point Likert-type scale, with 5 representing strongly agree and 1 representing strongly disagree. These items were developed based on several instruments on group work, PBL, and distance education course evaluation (e.g., De Simone et al., 2001; Kouros, 2000). The attitude questionnaire was administered at the end of the semester.

Results

Analysis of online discourse, journal entries, project performance, and attitude surveys indicated a variety of ways in which between-group collaboration appeared to have positive impact on student learning in complex problem solving. These findings are presented below under the following sub-headings: group processes, project performance, achievement tests, and attitude questionnaire.

Group Processes

Group work online can be both rewarding and frustrating. The between-group observation and reflection activity at mid-semester helped the students see, through personal experience, some common problems in online group work, and also see how different strategies appeared to result in different group dynamics and project outcomes. One such problem was lack of participation or late participation by some group members. The following are excerpts of students' comments about this problem in an online class discussion forum.

One student, frustrated with the participation problems of some group
members, commented after observing other groups’ online collaboration discourse:

I feel better now. As I read some other group postings, I noticed that every group seems to be having trouble with some members not participating in a timely manner.

A student in another group replied:

I can empathize with your feelings in reference to the group work and the responsibility of the learner. However, I see this as just one of the common challenges that will take place in building or working in an online community, such as an online course.

A student in the third group commented:

Group work is a learning experience. The focus here is what we learn[,] not the members who do not pull their weight. I really do not feel frustrated. If things are not moving along, I post a message in my group area stating that we need to get going. I also write that I will move forward with the suggestions made if no one answers me. It seems to be working.

Another student observed:

I saw that a group used alternate communication methods (phone, also tried Chat). Also, certain groups were waiting for everyone to be ready which led to lateness, whereas others chose to solve that problem by carrying on with work, not waiting on late people. It seems this last solution was more productive.

Some students pointed out the importance of defining roles:

I have found ... from visiting [other groups’ online collaboration discourse] it is very important and essential that the roles of the group members are defined at the beginning of the course. By doing so, each member will know well in advance what they have to do and what is expected of them before it is too late. This will eliminate a lot of confusion and late assignments. It will also eliminate one person from doing all the work.

Students also noticed and commented on different leadership styles in different groups. In one group, one student initiated and took the lead in most of the group activities and others gladly followed along. In another group, one student would take the lead in one activity and then invite other group members to do so in other activities, effectively rotating the leadership role. In the third group, there was no clear leadership role. Each member tried to act as a leader at certain points, and none seemed to be listening to the others very well. Observing and discussing the strengths and limitations of different leadership styles appeared to have a positive impact on each group.

Discourse analyses, as well as instructor observation during the course, indicated that the groups appeared to pick up some of the positive aspects of working styles and suggestions from other groups. In the second half of the semester, all three groups seemed to be sharing leadership roles and working together more enjoyably and cohesively. One member commented: “Since this forum has been posted, my group has done a much better job of communicat-
ing and working together.” Another commented: “This group process is one that is frustrating and difficult at times, but can also be so rewarding. This discussion has really helped me to see the trends in group dynamics.”

Project Performance

Between-group observation experiences not only helped each group work more enjoyably and equally together, they also helped the students see the strengths and limitations of each project as well as common challenges. The following are excerpts of a dialogue in which students were discussing some common challenges in designing their mini-course as a group:

It seems as though the other teams are experiencing some of the difficulties that we are experiencing. I noticed that both teams were concerned with repetitive teaching and learning strategies that would lead to participants being bored. Pacing and timing are also concerns for all of us. It is difficult to keep the lessons concise so that all activities can be completed within the two-week time frame and at the same time keep it interesting and engaging. Trying to establish some type of link or transition between modules is very difficult when each person is working independent of others.

One student suggested:

One way that groups could avoid strategy repetition would be to make a list of possible strategies and have group members pick which ones they are planning to use. If several members pick the same strategy, discussion could take place to decide [in which module] the strategy would be most effective. . . . Once the mini-courses are developed, members within each group should complete each other’s modules as a trial run to identify problems, unclear areas, and other bugs that need to be worked out.

Within-group module review and observing other group projects led to considerable improvements being made before mini-course implementation. These improvements included: providing more detail in the course syllabus, keeping course format and structure more consistent across the modules, making instructions detailed and clearer, balancing the amount of work required across the modules, and using a variety of instructional strategies within each module and across modules to better engage and motivate the participants.

During the mini-course implementation, several students encountered unexpected challenges in teaching their modules and were able to make appropriate adjustments. For example, one course included some PowerPoint™ game templates for the participants to download and then use to create their own subject-specific games for students. One participant was not able to download and open the template in its correct format. Several alternative methods were suggested by the group members and were tried in order to solve the problem. In another mini-course, a chat session was scheduled, but because of a change of date at short notice, only one participant was at the chat on time. To make up for the activity, the instructor was able to post a modified asynchronous
activity for the other participants. In the third mini-course, two module instructors designed and developed sophisticated tutorials using screen activity recording software. Although they were aware of file size problems and tried to keep each file small, some participants using modem connections still had a problem downloading them within reasonable time. Seeing the problem with the first module, the instructor of a later module modified his tutorials to reduce the file sizes further.

During the 2-week implementation, each student was required to teach their own mini-course, take a mini-course they signed up for, and observe a third mini-course they were neither teaching nor taking. To record their thoughts and reflections on each of the three courses, each student was required to keep a daily journal. After 1 week of course implementation, the journal observations about each course were summarized by the instructor and made available to each group for encouragement as well as possible improvement.

On the whole, the mini-course implementation was a great success. Although the 2 weeks were filled with intense activity, each student commented in their journals that they greatly appreciated the opportunity to actually implement their mini-course between groups in the class because it gave them the real experience of teaching an online course, solving complex unexpected problems during implementation, and seeing both the strengths of their course design strategies and areas for improvement.

At the conclusion of the implementation, each group discussed successes and problems encountered during implementation and made several revisions to its mini-course syllabus and modules. Most of these revisions focused on providing clearer directions about course activities and assignment expectations. One group made some adjustment in the resources and activities for each module so as to make its mini-course more coherent.

**Achievement Tests**

Table 1 presents the results of the pretest and the posttest that were designed to measure each student's ability to solve complex problems in designing online courses. Overall, students made significant progress from the pretest (mean = 82.45) to the posttest (mean = 87.59) (p < 0.01). Although the course descriptions were of similar detail in the two versions, there were significant differences in all the other three aspects, including the description of the rationale for course redesign (p < 0.01), description of expected challenges in designing and offering the course online (p < 0.01), and the recommendation of appropriate instructional strategies (p < 0.01). In the posttest, the majority of students foresaw a wider variety of challenges in redesigning a face-to-face course for online delivery. The challenges anticipated and strategies recommended were not only about the course design but also about course implementation. For example, many students included more detailed description of assignment expectations and group collaboration procedures for a smoother course implementation. The instructional strategies were also described in
greater depth and appeared to be more creative, taking into consideration learner and content characteristics, as well as attributes of technology tools available or possible in current course management systems such as Blackboard™.

**Attitude Questionnaire**

The results of the attitude questionnaire are presented in Tables 2 and 3. Table 2 reports students’ general preferences for individual or group projects and their perceptions of within-group and between-group collaboration in this class. About one third of the students responded that they usually liked working on group projects more than individual projects; one third had the opposite preference; and one third were neutral with respect to their preferences for group or individual projects.

On the within-group collaboration items, 100% of the students agreed that they worked well as a team and that they learned a lot from working through the mini-course design with their group members; 82% responded that their contributions in their groups were usually valued; and 63% responded that the within-group review and tryout were helpful.

Items 6–10 asked about students’ perceptions of the cognitive benefits of between-group collaboration. One hundred percent of the students agreed that the cross-group implementation of the projects was a valuable experience, that the actual implementation of the mini-course helped them see the strengths and limitations of their course design that they had not seen before the implementation, and that they felt more confident that they could solve complex online course design and implementation problems as a result of the projects they completed in the course. Ninety-one percent agreed that reviewing and observing other teams’ work was helpful in seeing the strengths and limitations of their own work as well as others’, and that the opportunity to take and observe other teams’ courses helped them learn more about potential problems and effective strategies in designing and implementing online courses.

Items 11–14 focused on the motivational benefits of between-group collabo-
Table 2. Student perceptions about within-group and between-group collaboration

<table>
<thead>
<tr>
<th>Items</th>
<th>Responses&lt;sup&gt;a&lt;/sup&gt;</th>
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<tbody>
<tr>
<td></td>
<td>5</td>
</tr>
<tr>
<td>General preference</td>
<td></td>
</tr>
<tr>
<td>1. I usually like working in group projects more than individual projects</td>
<td>3</td>
</tr>
<tr>
<td>Within-group collaboration</td>
<td></td>
</tr>
<tr>
<td>2. I learned a lot through the mini-course design with my group members</td>
<td>3</td>
</tr>
<tr>
<td>3. The within-group peer review and tryout were helpful</td>
<td>4</td>
</tr>
<tr>
<td>4. Our group worked well as a team</td>
<td>4</td>
</tr>
<tr>
<td>5. My contributions in my group were usually valued</td>
<td>7</td>
</tr>
<tr>
<td>Between-group collaboration</td>
<td></td>
</tr>
<tr>
<td>6. The between-group implementation of our projects was a valuable experience to me</td>
<td>8</td>
</tr>
<tr>
<td>7. The actual implementation of our mini-course helped me see the strengths and limitations of our course design that I didn’t see before the implementation</td>
<td>10</td>
</tr>
<tr>
<td>8. Reviewing and observing other teams’ work was helpful in seeing the strengths and limitations of our own work as well as others’</td>
<td>8</td>
</tr>
<tr>
<td>9. I feel more confident that I can solve complex online course design and implementation problems through the projects we completed in this course</td>
<td>8</td>
</tr>
<tr>
<td>10. The opportunity to take and observe other teams’ mini-courses helped me to learn more about potential problems and effective strategies in designing and implementing online courses</td>
<td>6</td>
</tr>
<tr>
<td>11. The opportunity of actually designing and teaching a mini-course to our classmates motivated me to work harder and produce better quality work</td>
<td>6</td>
</tr>
<tr>
<td>12. The cross-group teaching made this course more challenging and more meaningful</td>
<td>5</td>
</tr>
<tr>
<td>13. Looking at projects done better than ours motivated us to put forth more effort</td>
<td>3</td>
</tr>
<tr>
<td>14. I liked the opportunity to observe other projects’ design and implementation</td>
<td>5</td>
</tr>
<tr>
<td>Within-group and between-group collaboration</td>
<td></td>
</tr>
<tr>
<td>15. The within-group and between-group collaborative learning strategies in this course were well designed and helpful</td>
<td>4</td>
</tr>
<tr>
<td>16. I enjoyed interacting with other students in this class</td>
<td>6</td>
</tr>
<tr>
<td>17. Online collaborative learning activities in this course were challenging but rewarding</td>
<td>5</td>
</tr>
<tr>
<td>18. I felt like I was part of a learning community in this class</td>
<td>4</td>
</tr>
<tr>
<td>19. I liked to work in our small team while being able to observe how other teams were doing</td>
<td>4</td>
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<sup>a</sup>5 = strongly agree, 4 = agree, 3 = neutral, 2 = disagree, 1 = strongly disagree.
Table 3. Student perceptions about the course in general

<table>
<thead>
<tr>
<th>Items</th>
<th>Responses&lt;sup&gt;a&lt;/sup&gt;</th>
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<tbody>
<tr>
<td>----------------------------------------------------------------------</td>
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</tr>
<tr>
<td>1. I feel that I have learned more than I had expected before the course</td>
<td>7 3 1 0 0</td>
</tr>
<tr>
<td>2. I learned more than in a traditional face-to-face course</td>
<td>5 4 1 1 0</td>
</tr>
<tr>
<td>3. I liked that the course focused not just on discussion but more on actual application</td>
<td>9 2 0 0 0</td>
</tr>
<tr>
<td>4. The project-based learning experiences helped me achieve integrative higher-order learning in this course</td>
<td>5 5 1 0 0</td>
</tr>
<tr>
<td>5. The course was well organized</td>
<td>6 4 1 0 0</td>
</tr>
<tr>
<td>6. This course required more effort than a face-to-face course</td>
<td>8 1 0 1 1</td>
</tr>
<tr>
<td>7. I would recommend this distance education course to others</td>
<td>5 5 0 0 1</td>
</tr>
<tr>
<td>8. I would like to take another course like this one</td>
<td>5 3 3 0 0</td>
</tr>
<tr>
<td>9. The Blackboard&lt;sup&gt;™&lt;/sup&gt; course management system was helpful for my learning in this course</td>
<td>4 7 0 0 0</td>
</tr>
</tbody>
</table>

<sup>a</sup>5 = strongly agree, 4 = agree, 3 = neutral, 2 = disagree, 1 = strongly disagree.

ration. Ninety percent of the students felt that the cross-group teaching made this course more challenging and more meaningful. Eighty-two percent agreed that the opportunity to actually design and teach a mini-course to their classmates motivated them to work harder and to produce better quality work and that they liked the opportunity to observe other projects’ design and implementation.

Items 15–19 asked about students’ perceptions of within- and between-group collaboration. One hundred percent of the students agreed that the online collaborative learning activities in this course were challenging but rewarding. Ninety-one percent felt that the within- and between-group collaborative learning strategies in this course were well designed and helpful, and that they enjoyed interacting with other students in the class. Eighty-two percent of the students agreed that they were part of a learning community in the class, and that they liked to work in their small team while being able to observe how other teams were doing.

Table 3 presents the results of students’ perceptions about the course in general. One hundred percent of the students agreed that they liked the fact that the course focused not only on discussion but more on actual application and that the Blackboard<sup>™</sup> course management system aided their learning. Ninety-one percent responded that they learned more than they had expected before taking the course, that the PBL experiences helped them achieve integrative higher order learning in the course, and that they would recommend this course to others.
Discussion

Online courses have been criticized for their focus on knowledge acquisition rather than on how to solve authentic complex problems, which is increasingly being recognized as critical to meeting the challenges in the real world (Clark, 2003; Gutiérrez, 2000; Jonassen, 2002; Marra & Jonassen, 2001; Morley, 2000). The purpose of this study was to explore whether and how between-group collaboration can promote student learning of complex problem solving in project-based online courses. Two between-group collaboration strategies—(a) between-group project implementation and (b) between-group observation and reflection on project processes—were employed to help the students in an educational technology class develop complex problem-solving skills in designing online courses. The results from qualitative and quantitative data indicate that between-group collaboration had positive impacts on group processes, group project performance, individual student learning, and confidence of complex problem solving in designing online courses because it fostered communities of practice in the online classroom.

In real-world professions, problem-solving skills are often learned through engaging in solving a variety of real problems, and interacting with colleagues who are solving similar problems, thereby enabling the practitioner to gradually become a member of the community of practice (Wenger, 1997). Findings from this research indicate that communities of practice can also be fostered through peer collaboration within and across groups in project-based online courses. Studies (e.g., Thomas & MacGregor, 2001) investigating the nature of small group interactions show that members benefit from the exchange of multiple perspectives in their own group, but that the perspectives and resources are limited to the immediate group members only. By contrast, this study shows that between-group collaboration can allow students to extend their dialogue and exchanges beyond their own group. It helps the students to experience and reflect on a variety of complex problem-solving challenges and strategies in a supportive collegial environment.

The between-group observation and reflection helped the students view and analyze project processes in an objective way and try different strategies to improve these procedures. In the first half of the semester, when group areas were closed, some students felt personally frustrated with some of the challenges they encountered in their group because they thought these challenges were unique to their group. At mid-semester, when students had a chance to visit all project areas, they began to see patterns of group dynamics and the positive and negative consequences of different strategies employed in different groups. This prompted less effective groups to try the more effective strategies employed by other groups or to try new strategies. The observation and experiences resulted not only in improved group processes of less effective groups but also provided the students in this design class with valuable authentic case studies on group dynamics and project processes. This finding has both practical and theoretical implications. Between-group observation and
reflection on project processes may be employed by online educators to help all project groups work together more effectively. It can also provide online educators and researchers with a better understanding of challenges in online group projects so as to develop effective strategies and guidelines.

Between-group implementation made the projects more relevant and meaningful, which motivated students to exert more effort and to produce higher quality work. When designing a course for hypothetical target learners, the learner characteristics are often assumed and sometimes the designers tend to match learner characteristics to the course design rather than vice versa (Smith & Ragan, 1999). When students were required to design and teach their course for their peers, they realized in a more personally relevant and meaningful way the importance of selecting and designing instructional materials and strategies that would be appropriate for the target learners so that they would learn more effectively and enjoyably. The between-group course implementation provided the students with the opportunity to test their design strategies with each other and to see positive results as well as challenges. It gave students the opportunity to discern key issues such as clarity of instructional procedures, detailed description of assignment expectations, balance between structure and flexibility, different problems encountered with text-based and multimedia tutorials, availability of technology tools used, and problems with Internet services. It also provided the students with the opportunity to evaluate and revise their strategies in designing and implementing online courses. These findings indicate that between-group project implementation is an effective strategy for training online course developers and educators. Between-group project implementation may also be helpful in other instructional design courses to promote complex problem solving in instructional design. Future research should investigate this possibility and how between-group project implementation may be employed to enhance PBL in other subject areas.

Because of different course goals, content characteristics, and learner characteristics such as learning styles, motivation level, and technology expertise and availability, each mini-course was designed and implemented in a different way. This provided the students with an opportunity to experience a wider variety of projects and to solve a variety of authentic and challenging problems. Experience with and reflection on a wider variety of projects with their unique as well as common challenges and possible problem-solving strategies resulted not only in the groups’ higher quality project performance but also in the enhancement of each student’s learning. These findings are especially important for other online educators who are using or considering using PBL to promote the learning of complex problem solving in their online courses. When a small group of students work on a novel and ill-structured real-world problem, many students often feel insecure and uncertain as a result of their lack of experience, limited content knowledge and the habit of looking for one correct answer. Thus, they are limited in their ability to come up with alternative solutions. The opportunity to observe and reflect on peer projects—both the processes and products and the challenges and strategies—broadens
students' repertoires of possible challenges, alternative strategies, and best solutions.

The results of this study support Clark's (1983, 1994, 2000, 2003) and others' views that instructional methods are more important than media alone in helping students to learn. Creating an interactive online learning environment that promotes problem solving and critical thinking requires more than the technological environments (Bullen, 1999). In this study, the Blackboard™ course management system made it possible to capture the online discourse of each project group's collaborating processes, but it requires the design and implementation of between-group collaboration strategies to enable the teams to observe and reflect on each others' project processes, challenges encountered, and consequences of different strategies. The results of this study suggest that the design of the online course environment should focus not only on how resources and functionalities are built into the course platform but also on how collaborative environments can be structured to engage students in solving authentic complex problems with the support of not only the instructor but also peers working on similar problems.

Overall, the findings of this study indicate that between-group collaboration can be used as a viable instructional strategy to enhance student learning of complex problem solving in project-based online courses. Several new instructional design models have recently been developed for teaching complex problem solving. The findings of this study are consistent with Van Merriënboer's (1997) Four Component Instructional Design Model in emphasizing the importance of project processes and practicing the whole task. Although the design of within-group project collaboration in this study followed Nelson's (1997) Collaborative Problem Solving Model, the findings indicate that designing a collaborative environment for small within-group collaboration may not be sufficient because it misses the opportunity for teams to learn from each other whether for group processes, project performance or individual learning in solving complex problems. A future collaborative problem-solving model should consider including between-group collaborative learning strategies to foster communities of practice and develop complex problem-solving skills.

**Limitations and Future Research**

This study is exploratory in nature. Owing to the small sample size, the results may be limited in generalization. Several studies are planned to replicate the findings in similar and different types of courses and to test the results through controlled experimental research.

**Note on Contributor**

Yiping Lou is Assistant Professor in the Department of Educational Leadership, Research and Counseling at Louisiana State University. Her
research is focused on technology-mediated instruction, online pedagogy, and collaborative learning.

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