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Enhancing Project-Based Learning Through Online Between-Group Collaboration

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ABSTRACT

This research explored how between-group collaboration enhanced the co-construction of knowledge and performance on project-based learning tasks of collaborative learning groups. The findings of 2 case studies, one that focused on between-group mentoring and one that focused on between-group project review, revealed that both strategies were perceived favorably by the students and had a positive impact on the collaborative learning skills, the knowledge revealed through their online dialogue, and the project performance of all students, especially the less effective groups. The results provide some insights into the computer-supported collaborative learning process among students in a higher education context.

INTRODUCTION

Higher education has been influenced in recent years by challenges to reconsider how learning environments and processes are viewed and how new technologies can be utilized to enhance learning (Chickering & Gamson, 1987; Magolda, 1992; Pascarella & Terenzini, 1998). Social constructivist viewpoints, sociocultural theories, and principles of situated cognition have all contributed to a greater interest in how the social aspects of learning are reshaped and enhanced by the technological tools that are used to support instruction (Koschmann, 1996). An important suggestion for improving instruction is to make a shift from traditional pedagogies that are instructor centered to a social-constructivist paradigm where students are encouraged not only to work individually to solve relevant problems in the academic

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disciplines, but also to work collaboratively with their peers through student-centered learning activities (National Research Council, 1996; National Science Foundation, 1996) in both face-to-face classrooms and online environments (American Psychological Association, 2002; Institute for Higher Education Policy, 2000). This project examines how online between-group collaboration can enhance project-based learning in higher education.

Project-Based Collaborative Learning

Project-based learning, as a student-centered pedagogical approach, is gaining widespread interest in higher education. An underlying principle of project-based learning is that a theme or problem to be solved is established and students gradually explore the problem from different perspectives, adjust their goals and strategies to new insights gathered during the project (Poell, Van der Krogt, & Wildemeersch, 1998). Student projects offer an ideal situation to provide problem-solving opportunities that present real-world problems that are scaled back so that they are doable in the confines of the classroom. Project-based learning can be thought of as learning through a series of theme-related activities that are based in authentic, real-world problems in which the learner has a certain amount of control over the learning environment and the design of the learning activities (Morgan, 1987).

One, if not the most, important component in the implementation of project-based learning is the facilitation of group working structures (Livingstone & Lynch, 2000). Project-based learning and collaborative learning are highly compatible and in a way are essential to each other for effective implementation into the university classroom. In this context, students with varying levels of knowledge and prior experiences work together in small groups toward a common goal. From a social constructivist perspective, collaboration among students promotes participation and the mutual development of knowledge (Salomon, 1993). The students are responsible for one another's learning as well as their own, which requires group interdependence, motivation, persistence, and flexibility (Abrami et al., 1995). Socially contextualized learning motivates students to be actively involved and to take greater responsibility for directing their learning activities (Harrison & Stephen, 1996; Resnick, 1989).

Several meta-analyses of small-group collaborative learning research (e.g., Lou, Abrami, & d'Apollonia, 2001; Lou et al., 1996; Springer, Stanne, &

Donovan, 1999) indicate that on average students at all levels of education learned more and had more favorable attitudes toward learning when working in small collaborative groups than individually in either technology-mediated learning environments or traditional classrooms. However, the meta-analytic reviews also found that the effects of small-group learning were not consistent across the studies and were moderated by a number of pedagogical and contextual characteristics. It has been noted that in order for the positive effects of small-group learning to occur, students must possess the necessary skills of collaboration (Bosworth, 1994). These include, but are not limited to interpersonal or social skills (openness and solidarity), group management/ development skills (involvement and control), and inquiry skills (clarification, inference, judgment, and strategies) (Henri, 1991; Lundgren, 1977; McDonald & Gibson, 1998).

Project-Based Collaborative Learning in Online Environments

Online instruction is gaining popularity as a means to support the learning process for students in both traditional and distance learning courses. Although the number of quality empirical studies is still limited, an emerging body of research comparing the effects of online instruction versus traditional face-to-face classroom instruction indicates that if online instruction is implemented using sound pedagogical strategies, it can be more effective or equally effective as face-to-face instruction (Bernard, Lou, & Abrami, 2003). A strong criticism of media comparison studies is the possible confounding effects of instructional methods and media (Clark, 1983, 1994, 2000). However, others (e.g., Kozma, 1991, 1994; Smith & Dillon, 1999) argue that it cannot be denied that different media have unique attributes and if used appropriately, they could support student learning in a more effective way. Whether one sides with Clark or Kozma, the long debate underscores the importance of pedagogy and systematic design in creating technology-mediated learning environments to support student learning.

Various instructional methods can be utilized to foster social interaction in cyberspace (Palloff & Pratt, 1999). The use of case studies, role-playing, debate, and threaded discussion on issues are recommended to help establish a sense of community and engagement in the learning process. Project-based learning is amenable to implementation in the online learning environment. Small groups of students can collaborate on a project using group areas in course management systems such as Blackboard™. In their research, Wang, Pool, Harris, and Wangemann (2001) found that students engaged in

project-based learning online gained deeper content knowledge and higher level problem-solving skills through discussing project goals and designing strategies and solutions with group members. Other studies on group interaction in online environments indicate that online learning experiences that include interaction with content, active participation, and collaboration facilitate the social construction of meaning (Hiltz, Fjermestad, & Lewis, 1999); that creating a community of learners where knowledge is constructed alone and together with others in ways that promote social and intellectual development is an important ingredient in successful distance learning (De Simone, Lou, & Schmid, 2001; Rendon, 1994; Tinto, 1998); and that the extension of the classroom beyond normally scheduled class time offers students the possibility to continue dialog and bridges barriers that are often created by inequities in the balance of power that may exist in the classroom (McComb, 1994).

When students use the online environment for the development and production of course projects, the importance of both the process and product of the activity has been noted (Caplow & Kardash, 1995). Through content analysis of students' online discourse, the presence of emerging knowledge and insights can be documented. A recent research project (Thomas & MacGregor, in press), in which the online collaboration of student groups engaged in project-based learning was analyzed, demonstrated that groups were not equally successful in their ability to collaborate toward an instructional goal. The interactions of high achieving groups revealed that the members shared leadership responsibilities, distributed tasks evenly and according to their individual talents, and were able to define, understand, and respond to task demands. However, teacher facilitation and monitoring of the process didn't result in much improvement by the lower achieving groups. Similar findings were noted in Wang et al. (2001).

Between-Group Collaboration

Between-group collaboration, here, refers to the collaboration across small groups of students working on different projects. The concept of between-group collaboration in project-based learning is analogous to "communities of practice" in the professional world, which is often defined as groups of professionals who work on similar problems, and therefore, employ similar tools, use the same language, and share similar goals (Wenger, 1997). Because of limited perspectives and experiences, the problem solutions by each

individual or project group are often limited. Therefore, members of a community of practice often come together to learn from each other, to exchange expertise and ideas, and to build collective knowledge.

A few preliminary studies on the use of between-group collaboration in online learning environments suggest that students responded positively to between-group collaboration in project-based learning (Lou, Dedic, & Rosenfield, 2003). De Simone et al. (2001) conducted a study on learning in an undergraduate educational psychology distance education class that used open access group forums using First Class™. 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 liked to visit other groups to see how other groups were doing, to ask questions, and to share learning strategies.

The purpose of this research was to provide further understanding of the processes and outcomes of an online learning environment in which project-based, between-group collaboration was implemented. Specifically, the questions guiding this research were:

1. In what ways does online between-group collaboration enhance the performance of small collaborative groups? Does between-group collaboration improve the quality of collaboration as reflected by the cognitive levels of discourse? Does between-group collaboration enhance the quality of group projects?
2. What perceptions do students have about their online between-group collaborative learning experiences?

METHOD

Research Design and Participants

This study employed a mixed method design integrating both qualitative and quantitative data. Through the collection of both types of data, a more comprehensive understanding of a research problem is possible (Creswell, 2002). Qualitative data sources included transcripts of student discourse while they were engaged in communications related to working on group projects. Quantitative data included project grades and student responses to a Likert-scale questionnaire.

The participants were enrolled in two classes in the College of Education of a large research university. Both classes utilized online learning environments

to support collaborative learning. Each class was considered to be an illuminative case that would provide information about the impact of between-group collaboration on learning. In Case A, the participants were 18 (14 female, 4 male) graduate students enrolled in an educational research course that met primarily online. There were two class meetings held to cover topics deemed too complex for the online format. In Case B, the participants were 18 (16 female, 2 male) junior or senior undergraduate and beginning graduate students enrolled in an educational technology course that met primarily in a face-to-face format with group assignments conducted online.

Data Sources

Data were collected over the duration of a semester and included transcripts of each group's online discourse, completed projects, and students' responses to an attitude questionnaire. Students were informed that their online dialog would be monitored and considered as a component of their project grades. At the end of the semester, permission was requested and received from students to use their communication for research purposes.

Online Discourse

Transcripts of all online dialog that occurred while students worked toward task completion were analyzed to provide information about the nature of the groups' discourse. One challenge for researchers is to understand the dynamics of the collaboration process to document the contributions that occur from components of the activity system (Lee & Majors, 2003). Categories for classifying the nature of the exchanges were based upon models of verbal interaction and content analysis (Henri, 1991; Howell-Richardson & Mellar, 1996; Lee, Liang, & Chan, 1999). Categories of interaction were designated as either task-related (e.g., making suggestions, questioning or accepting ideas) or socio-affective (e.g., humor, group building, and personal criticism). Task-related interactions also can be categorized as those that reflect higher or lower levels of critical thinking (Angeli, Valanides, & Bonk, 2003). In this study, higher levels included making alternative suggestions, questioning ideas/positions on issues, identifying limitations in ideas, expressing disagreement, providing cognitive elaboration and explanation, and organizing/management, that demonstrate more critical thinking; lower levels included questioning for clarification of facts/details, identifying limitations in details, providing clarification, accepting/agreeing/praising in general, and making declarative statements.

During the transcript coding, the unit of analysis was determined by the content and intent of each sentence in each posted message. Multiple sentences with the same intent were considered to be one message unit. To establish reliability for coding units, samples of messages were coded by two raters. At the start, there was an inter-rater agreement of 50%. Discussion was conducted for the purpose of clarifying the meaning of the codes and code labels. Practice coding of samples was continued until inter-rater agreement exceeded 80%.

Project Performance

Each group project was evaluated using rubrics that were designed to assess the presence and quality of key elements according to the project requirements. For example, in the WebQuest design project in the educational technology class, the key elements included the motivational appeal of introduction, cognitive level of task, clarity of task procedures, adequacy of resources, clarity of evaluation criteria, et cetera (Dodge, 1995, 2001). For each key element, sample characteristics at three levels of competence, beginning, developing, and accomplished, were described so that they served both as project guidelines and assessment criteria. All projects were graded by each course instructor.

Attitude Questionnaire

Student perceptions of the between-group collaborative learning experiences were elicited using a Likert-scale attitude questionnaire that was adapted from SAGE (Kouros, 2000), an attitude questionnaire that included a variety of items about small-group collaborative learning and its instructional effectiveness. For the purpose of this article, only eight questions that focused on student perceptions of how the between-group collaboration affected their learning and motivation were included in the analyses. The attitude questionnaire was administered at the end of the semester.

Procedures

At the beginning of the semester, students in both classes were randomly assigned to collaborative groups each consisting of two to four members. In both courses, the Blackboard™ course management system was used for online group collaboration. During the first half of the semester, the students were engaged in project-based collaborative learning within small groups. The projects were designed to provide students with activities that required them to

apply course concepts and skills to authentic project-based learning tasks or to the evaluation of current controversial issues. Each group was provided with a private group area in which they used the threaded discussion forums, virtual chat, and drop box. The quality of each project produced by the collaborative groups was evaluated using rubrics. At mid-semester, a mean group score was determined for the set of project scores earned by each group. Then a class mean was calculated based on all the group means. The groups with scores above this mean were rated as more effective and the groups with scores below this mean were rated as less effective.

To determine if the quality of group projects was due to the differences in individual student's ability and/or knowledge of course content, the results of the midterm examination were examined in each class. A mean score was calculated for all students in the less effective groups and was compared to that of all students in the more effective groups. No significant differences between the mean scores of students in the more and less effective groups were found in either class.

To help more and less effective groups to learn from each other, between-group collaboration was implemented in each class at mid-semester. In Case A, where group collaboration was primarily online, a mentoring approach of between-group collaboration was employed. In Case B, where group collaboration occurred both online and offline, between-group project review was employed.

Case A: Between-Group Mentoring

In addition to evaluating the collaborative projects, the online dialog of each group in the educational research class was analyzed at mid-semester. There was a clear difference in both the quality and quantity of the online dialog of the groups that demonstrated better performance when compared to those groups with lower performance on the assigned project-based learning tasks. In the more effective groups, there were more postings and more equitable participation among group members. With respect to content, the dialog of the more effective groups was characterized by questioning, offerings of suggestions and alternative solutions, organizational plans, and frequent compliments and messages of support. In contrast, the less effective groups made declarative statements, asked very few questions, accepted the first offered solution, and revealed little, if any, organizational plans. Therefore, it was determined that the between-group activities would be designed to provide opportunities for the more effective groups to mentor the less effective groups.

Each of the three groups rated as more effective was paired with a less effective group. The newly formed group pairs were given access to each other's group space on Blackboard™. The groups were directed to reflect on how their group process was similar or dissimilar to their partner group and to provide constructive feedback relevant to their partner group's progress. The implicit objective was for the more effective group to mentor the less effective group by providing a model of high level interaction. Three more projects were assigned to the groups to be completed during the second half of the semester. Each project was conducted over a 2-week timeline. The project assignment guidelines provided a list of required elements and informed the students that the dialog leading up to the completion of the project and the final product would be evaluated as well.

Case B: Between-Group Project Review

For Case B, the educational technology class, preservice and inservice teachers were learning to design technology-integrated lessons and activities. In the first half of the semester, students were engaged in individual and small-group design projects. Because most students had limited design and teaching experiences, the products they designed often overlooked certain aspects such as details of procedures, difficulty level of tasks for a certain age group, and classroom structure and management strategies. Although the instructor provided detailed individualized feedback on each group project, project quality continued to vary considerably among the groups.

In the second half of the semester, between-group collaboration was implemented. Each more effective group was paired with a less effective group. Open forums were created on the class discussion board for each group to post their work and receive feedback from others. Students were encouraged to read all other projects and required to provide constructive feedback to their partner group. The purpose of the between-group project review was for groups to learn from each other through reviewing other projects, providing constructive feedback as well as receiving constructive feedback from others so as to develop high level critical thinking skills and self-regulation. In addition, it was hoped that reviewing other groups' projects would provide students with more perspectives and would help them to be more sensitive to the potential benefits as well as problems that may arise in the design and implementation of technology-mediated learning activities. A few strategies were used to provide guidance and scaffolding so as to effectively implement between-group project review. These included

instructor modeling, provision of an evaluation rubric, and class discussion of what constitutes the characteristics of a good design product.

RESULTS

Data from the online discourse, project performance, and the attitude questionnaire were analyzed to answer the research questions. The results corresponding to each major question are organized in the following subsections.

Impact of Between-Group Collaboration on Project Processes and Performance

Case A: Between-Group Mentoring

In the educational research class that was taught mainly online, between-group collaboration took the form of a more and less effective group joining the online conversation of their partner group. The online dialog sessions for the collaboration that occurred during the process of completing two projects were analyzed. For the purpose of this article, the second of three projects completed while working in small-group collaboration and the second of three projects completed while engaged in between-group collaboration were selected for analysis. The dialog sessions of the less (LE) and more effective (ME) groups were analyzed and indicated that the performance of the less effective groups was enhanced by the between-group collaboration. The improved performance of the less effective groups was demonstrated by both the depth and quality of their dialog as well as their project grades. Whereas there was a difference in the mean project grade for the less effective as compared to the more effective groups when they engaged in small-group collaboration ($M = 86.67$, $SD = 12.69$ for the LE groups; $M = 95.21$, $SD = 4.75$ for the ME groups), there was little difference in the mean project grades when they participated in the between-group partnering ($M = 93.17$, $SD = 5.85$ for the LE groups; $M = 94.83$, $SD = 4.30$ for the ME groups).

The data in Table 1 were derived from the content analysis of the messages posted by each group. A mean frequency across groups for each message category was computed for the three less effective and three more effective groups. Although the partner group members contributed to the discussions, only the postings of the primary group members are included in the data presented in Table 1. The analysis revealed that the quantity, extensiveness,

Table 1. Mean Number of Message Units of Group Interactions in Case A.

Categories	Small-group project		Between-group project	
	LE	ME	LE	ME
Task-related				
Higher level				
Making alternative suggestions	0.0	4.5	8.5	9.5
Questioning ideas/positions on issues	0.0	3.5	5.0	4.5
Expressing disagreement	0.0	1.5	2.5	3.5
Providing cognitive elaboration/explanation	1.5	2.5	2.0	3.0
Organizing/management	0.5	3.0	3.0	3.0
Total higher level	2.0	15.0	21.0	23.5
Lower level				
Making declarative statement	3.0	8.5	6.0	8.0
Accepting/agreeing	0.5	5.0	4.0	8.0
Questioning for clarification of facts or details	0.5	1.5	3.5	7.0
Providing clarification	0.5	1.0	1.0	2.5
Total lower level	4.5	16.0	14.5	25.5
Socio-affective	0.0	1.5	6.5	3.0

Note. LE = less effective groups; ME = more effective groups.

and depth of their message postings increased. More specifically, the less effective groups offered more higher cognitive level task-related message units such as making alternative suggestions, questioning ideas or positions on issues, expressing disagreements, making more organizational statements, and made more comments of the socio-affective nature.

The following are examples of postings that represent each category of message unit in project-based group collaboration:

- Making Alternative Suggestions: "My thinking was to keep along the same line with our standardized test. So we have one group with treatment and one without. We could use a t test because we have two groups."
- Questioning Ideas/Positions: "I agree with you that there should be adequate and equal funding for all schools. However, this is not the only issue in educational equality. Please give some suggestions on other ways that we can reach educational equality for our students."

- Expressing Disagreement: "According to my information a hypothesis does not include the name of a specific instrument. That goes in the method section."
- Providing Cognitive Elaboration: "Concerning your question about math journals. My experience has been that the teacher can use them in any way she/he wants. I used them with my students with more specific daily suggestions to get them started."
- Organizing/Management: "O.K. Let me explain what I think we need to do for this task. The followings are my ideas for the steps of this task . . . If you agree with my ideas of these steps, I can work on the job for step number one and we can each do one step."
- Making Declarative Statement: "We need to make up hypothetical scores for each student."
- Accepting/Agreeing: "I agree with you. I looked over the text, and I came up with the same conclusion."
- Questioning for Clarification of Facts or Details: "Since you've given the ITBS, I thought you might know what kind of scores the math concept section produces. Do you know, or should we look it up somewhere?"
- Providing Clarification: "With regard to your question about content validity, the STAR Reading Test does test what it was designed to – reading ability."
- Socio-affective: "Good to hear that someone else speaks Spanish. I know that I need to continue with the project so I appreciate your encouragement."

After the pairing of the two groups, a slow, but significant change occurred in the dialog of the less effective group. The following excerpt was taken from an exchange of the members of a more effective group, the Guides and a less effective group, the Greenhorns. At first, the Greenhorns just lurked, peeking in on the discussion of the Guides. Finally, about halfway into the project, one of the Greenhorns posted the following message: "I just wanted to let you know that I've been following your work." She then proceeded to make a contribution to the discussion. The Guides, patient and persistent, checked in on the Greenhorns' discussion contributing when they could. A Guide noted: "Hello from the Guides. I just wanted to say that I read your plan and am really interested in the subject you have chosen. With all the interest on your topic, it would be great to find out the results of your proposed action research project." Another Guide offered, "Your topic sounds like a very relevant one, with all the debate over how to teach reading. I look forward to see how it

works out." Finally, a second Greenhorn commented, "Thanks for the comments on our board. It seems that you guys have more insight into our project than we do." The early participation by the Guides expressed support and encouragement. Finally, after the Greenhorns acknowledged their input, a Guide offered a suggestion: "It looks like your group is comparing two methods of reading. Personally, I think that will be more interesting if you consider their effectiveness for different levels of ability." A response from a Greenhorn, "Your suggestion is great... as a matter fact, I thought your comments were so astute that I've placed your comments into my file of possible dissertation topics." Within the Greenhorn group statements of support began to appear. From one student to another: "You are a goddess. I am speechless." And they started to take risks and request feedback from each other. A student offered, "Here's what I think about discussion question 1... What do you think? Agree, Disagree, Think I'm loopy? Let me know!" A revelation of a Greenhorn provides insight into the power of the between-group process.

> I have looked into the dialogues of the Guides. They totally amaze me! They get along real well and seem to be at the computer all the time communicating with each other. I do think that we should try to communicate even if it is just a sentence per day like they do to make sure that we finish the project with ample time.

Case B: Between-Group Project Review

In the educational technology class where the class met twice a week, between-group collaboration took the form of groups reviewing each other's instructional design products. Although several guidance and scaffolding strategies were used, it took some practice time for all the students to develop skills in providing and valuing effective peer feedback. For example, in the first between-group project review experience soon after midterm, one group complained that the criticisms given by their partner group were too harsh to be acceptable. Through discussing the issue openly in class, as well as viewing some of the more balanced and tactful feedback provided by other groups, all students gradually learned to provide and value constructive feedback to each other and improved their projects based on the feedback they received.

Table 2 presents the mean frequency of message units for each feedback category provided by the more effective and less effective groups for the first and the last project. Members of both more and less effective groups were able

Table 2. Mean Number of Message Units of Between-Group Feedback in Case B.

Categories	Between-group project 1		Between-group project 2	
	LE	ME	LE	ME
Higher level				
Making suggestions	1.0	3.0	2.5	3.5
Questioning/identifying limitations in ideas	2.0	4.5	4.0	5.0
Providing cognitive elaboration/explanation	1.5	4.0	4.5	4.5
Identifying specific strengths	6.5	5.5	7.5	8.5
Total higher level	11.0	17	18.5	22.0
Lower level				
Identifying limitations in details	7.0	7.5	5.0	6.0
Accepting/praising in general	6.5	7.0	6.0	7.5
Total lower level	13.5	14.5	11.0	13.5

Note. LE = less effective groups; ME = more effective groups.

to identify specific strengths and limitations of surface-level features for each project according to the rubric. More effective groups provided a relatively greater frequency of higher cognitive level feedback such as making suggestions, questioning/identifying limitations in ideas, and providing cognitive elaboration/explanation in both of the between-group collaboration activities. Through practice and interaction with the more effective partner groups, the less effective groups provided more higher level feedback, especially in the cognitive elaboration/explanation category, in the later activity.

The following are examples of message units representing each category of between-group feedback:

- Making Suggestions: "I think it may help to tell the students exactly what you want them to include on their pamphlets."
- Questioning/Identifying Limitations in Ideas: "I thought the idea was a neat one. But it might be hard for fifth graders to do this activity because the concept of a time capsule is planning for the distance future, and that might lose their interest."
- Providing Elaboration/Explanation: "You need to provide more details regarding how the searches should be conducted and what to look for. Sometimes this age group may get too broad with their search."

- Identifying Specific Strengths: "The introduction got me interested and made me want to keep reading to see what was going to happen next. It also gave some background info to help the learner know that bugs are important to us and our lives."
- Identifying Limitations in Details: "How students will be evaluated was stated but not very clearly."
- Accepting/Praising in General: "I really enjoyed the activity you designed and I am sure fifth graders would feel the same way."

Several noticeable changes were observed in the revised group projects based on the between-group project review. One change was that almost all groups made significant improvements based on either the limitations identified or the suggestions made by their partner groups. Another change was the modeling effects of reviewing and noticing the specific strengths of other projects. Less effective groups applied some of the strategies used by more effective groups and subsequently improved their own projects. For example, in one project, the directions given for activity processes by a less effective group were not very clear. After seeing the clarity of steps through the use of one worksheet for each activity in their partner group's project, the less effective group appeared to adopt a similar strategy in their revision, which considerably improved their project quality. In the last between-group project, the mean project grades of both less effective and more effective groups increased considerably from their draft versions ($M = 79.21$, $SD = 5.57$ for the LE groups; $M = 86.71$, $SD = 2.72$ for the ME groups) to the final versions ($M = 89.63$, $SD = 2.78$ for the LE groups; $M = 93.71$, $SD = 2.46$ for the ME groups).

Student Perceptions of Between-Group Collaboration

Table 3 presents a summary of student perceptions of their between-group collaborative learning experiences from the attitude questionnaire administered at the end of the semester in both classes. Overall, students in both classes agreed that between-group collaboration had cognitive and motivational benefits.

For perceived cognitive benefits, the average rating of the four items ranged from 3.39 to 4.07 on a 5-point Likert scale. The most positive rating was on the item that having the opportunity to look at other groups' projects provided them with more perspectives as to how projects could be done. The mean ratings were above 4.00 for both types of groups in each class. The students also believed that reviewing and giving feedback between groups helped them to see strengths and limitations of their own and their partner's projects. The

Table 3. Student Perceptions of the Benefits of Online Between-Group Collaboration.

Items	Case A		Case B	
	LE *M (SD)*	ME *M (SD)*	LE *M (SD)*	ME *M (SD)*
Cognitive				
1. Opportunities to look at other groups' projects provided me with more perspectives as to how the projects could be done.	4.00 (0.58)	4.30 (0.48)	4.39 (0.76)	4.29 (0.49)
2. Reviewing other group's projects helped me see the strengths and limitations of our project and how we can improve it.	2.86 (1.46)	4.20 (0.63)	4.14 (0.38)	4.14 (0.69)
3. Reviewing and giving feedback helped us see strengths and limitations of both groups.	3.71 (0.95)	3.90 (0.88)	4.00 (0.00)	3.71 (0.95)
4. Feedback received from other groups improved our project.	2.57 (1.27)	2.90 (1.20)	3.86 (0.90)	3.57 (0.98)
Average	3.39 (0.59)	3.83 (0.50)	4.07 (0.37)	3.93 (0.72)
Motivational				
5. The opportunity to post our work online for others to review encouraged me to work harder and produce better quality work.	2.86 (1.77)	3.50 (1.43)	2.86 (0.90)	2.86 (1.26)
6. Looking at work done better than ours, motivated me to put in more effort.	3.14 (1.35)	3.40 (1.58)	3.71 (1.11)	3.43 (1.13)
7. Receiving positive feedback from other groups was rewarding and encouraging.	3.43 (0.71)	3.80 (0.79)	3.86 (1.35)	3.71 (0.95)
8. Receiving feedback from students in other groups was not a waste of time.	3.71 (0.95)	3.90 (0.74)	3.86 (0.38)	3.57 (0.98)
Average	3.29 (1.04)	3.65 (0.73)	3.57 (0.75)	3.39 (0.92)

Note. 1 = strongly disagree; 5 = strongly agree.

mean group ratings were between 3.71 and 4.00. For both items, the standard deviations were relatively small, indicating relatively consistent perception among the students.

For the perceived motivational benefits of the between-group collaboration, the average rating of the four items ranged from 3.29 to 3.65. The first two

items asked students whether they worked harder because of the between-group collaboration activities, the mean ratings were modest for all groups with relatively large standard deviations, indicating that while some students agreed that they worked harder, others disagreed. It is possible that the latter students may have believed that they were already working hard. The majority of students responded positively that receiving positive feedback from other groups was rewarding and encouraging. Among the four motivation items, the item that receiving feedback from students in other groups was not a waste of time received the most positive and consistent ratings from the students, indicating that students believed that the between-group collaboration activities were beneficial to them.

The above cognitive and motivational results appeared to suggest that, overall, the students felt that the between-group collaboration activities was a good use of their time, broadened their perspectives, and helped them see the strengths and limitations of their own and other groups' projects.

DISCUSSION AND CONCLUSION

This research explored how between-group collaboration enhanced the co-construction of knowledge and performance on project-based learning tasks of collaborative learning groups. The findings of two case studies, one that focused on between-group mentoring and one that focused on between-group project review, revealed that both strategies were perceived favorably by the students and had a positive impact on the collaborative learning skills, the knowledge revealed through their online dialog, and the project performance of all students, especially the less effective groups. The results provide some insights into the computer-supported collaborative process among students in a higher education context and how small-group project-based collaborative learning can be enhanced through either between-group mentoring or guided between-group project review.

Just as communities of practice in the professional world (Wenger, 1997), between-group collaboration provided the opportunities for project groups to exchange ideas and strategies and to learn from each other. When a small group of students works on a complex project, performance is generally enhanced with the collaborative efforts and multiple perspectives of the group members. However, the resources and insights within one group are still limited to the members present in the group. With little or no experience with the task

demands of similar projects, each group may feel, in a sense, alone and frustrated in struggling with its unique problems. Moreover, if the learning goal is to experience a variety of real-world problems, the experience of working on one project provides a very limited snapshot. Between-group collaboration expands learning beyond the limitations of one small group by building collaborative learning communities within the class. Groups working on similar projects learn from each other's strengths as well as weaknesses. The context and progress of other working projects provide each group with both motivational support and new insights. It turns the relationship between groups from one of indifference or competition into one of collaboration focusing on producing better quality projects and learning by all the members in the class.

The processes that occur in collaborative learning are complex and the online medium provides a vehicle for capturing the discourse that takes place in the process of learning. It enables the instructor to examine and analyze the progression and development of group projects and to intervene when necessary. A challenge for researchers is to understand the ways in which online discourse in educational contexts can be evaluated as well as nurtured to produce communities of learners. Rogoff (1995) provides a framework for considering the planes of focus in a sociocultural activity. Apprenticeship, guided participation, and participatory appropriation are individual, but interdependent components of this framework. In apprenticeship, a small group of peers may serve as a resource for less expert peers to challenge them to become more responsible participants. Mentoring may be considered a form of apprenticeship and its power in advancing the skill and understanding of individuals through participation with others in organized activities has been documented repeatedly (Lave & Wenger, 1991; Lee & Majors, 2003; Rogoff, 1995). A major finding of this research was how the mentoring of more effective groups influenced the cognitive level of interactions and project performance of less effective groups.

Lou et al. (2003) described a model of effective feedback for successful e-learning based on self-regulation. The authors argue that one of the reasons that learners often do not achieve high level goals is because they lack clear understanding and vision of the desired goal states. Therefore, in the model, both self and peers are considered important feedback sources. Peer collaboration through looking at others' work and providing constructive feedback helps learners develop clearer understanding of desired goal states and effective means for achieving the goals. The results of this research also indicate that reviewing draft products posted online by all groups broadens each group's perspectives and helps them to see the strengths and limitations

of their own and other group's work. Providing feedback to each other across groups helps students to develop critical thinking skills, self-regulating skills, as well as the skills in evaluating the work of others – a professional skill important for educators. Through evaluating each other's work, the students became more aware of possible areas of weaknesses in their projects. It enhances the transfer between conceptual understanding and applying newly learned concepts in their own projects and in evaluating other projects.

This research contributes to the existing literature on the use of online computer systems for implementing instructional activities in university courses. It provides insights on how online between-group collaboration can enhance group project collaboration processes and the quality of project performance. Because of the small sample size and exploratory nature of this research, however, the results of the study may be limited to the characteristics of this study. For example, it is possible that the between-group mentoring strategy may be more successful in online courses with graduate students. More research is needed to further investigate the effects of the two and other between-group collaboration strategies in various contexts and with students of different characteristics.

It is interesting to note that the students in both classes appeared to perceive higher cognitive benefits than motivational benefits of between-group collaboration. Although students appeared to vary in their opinion about whether between-group collaborative learning activities motivated them to put forth more effort, students in both classes agreed that it was a good use of their time. It has been noted that students can draw a less-interested peer into a higher level of engagement in online discussions (Schallert, Reed, & the D-Team, 2003–2004). Our results corroborate with these findings. Future research should explore in more depth the motivational impacts of between-group collaborative learning activities.

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