

Online Implementation of Project-Based Learning (PJBL) on Students' Capacity for Creative Thinking

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ABSTRACT

Creative thinking is the process of coming up with original, adaptable, and visually appealing solutions to problems. Creative thinking is the continuous process of thinking about and creating creative things in order to achieve objectives. Students find the project-based learning approach and the learning process to be interesting experiences. Student learning experiences with the upcoming project serve as the focus of the instructional materials. Students learn more and feel more motivated to complete assigned projects when they are given real-world experience in the learning process. Students learn more and feel more motivated to complete the assigned project when they are given real-world experience in the learning process. Creative thinking is the process of coming up with original, adaptable, and visually appealing solutions to problems. This study looked into how collaboration between groups improved collaborative learning groups' performance on project-based learning tasks and the co-construction of knowledge. The findings of two case studies, one on between-group mentoring and one on between-group project review, revealed that both strategies were viewed favorably by the students and had a positive impact on all students' project performance, particularly in the less effective groups, as well as the knowledge revealed through their online dialogue. The findings shed some light on how students in higher education engage in computer-supported collaborative learning.

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1. INTRODUCTION

In recent years, higher education has faced increasing demands to reconsider how learning environments are conceptualized and how emerging technologies can enhance instructional processes [1]–[3]. Influenced by social constructivist perspectives, sociocultural theories, and situated cognition, researchers have shown growing interest in how technological tools reshape and strengthen the social dimensions of learning [4].

A significant recommendation for improving instruction is the shift from traditional instructor-centered pedagogy toward a social-constructivist paradigm in which students actively construct knowledge through collaboration. In both face-to-face and online classrooms, students are encouraged to solve authentic problems individually and collaboratively through learner-centered

activities [5]–[8]. Within this context, this study investigates how project-based learning (PBL) in higher education can be enhanced through online between-group collaboration.

Project-based learning has gained increasing recognition as a student-centered instructional strategy. According to Poell, Van der Krogt, and Wildemeersch [9], PBL begins with a central theme or problem that students explore from multiple perspectives, continuously refining their goals and strategies as new insights emerge. Morgan [10] defines PBL as learning through authentic, theme-related activities grounded in real-world problems, where learners maintain partial control over the learning design and environment. Student projects provide structured opportunities for solving complex real-world problems within manageable classroom settings.

Effective implementation of PBL relies heavily on well-structured collaborative group work [11]. Collaborative learning and PBL are highly compatible, as students with diverse knowledge and experiences work together toward shared objectives. Collaboration encourages participation and mutual knowledge construction [12]. Because students are accountable for both individual and group learning, collaboration requires interdependence, motivation, persistence, and adaptability [13]. Socially contextualized learning environments further enhance engagement and personal responsibility [14], [15].

Online instruction has become increasingly prevalent in higher education. Research comparing online and face-to-face instruction suggests that when supported by sound pedagogical strategies, online learning can be equally effective [16]. While Clark [17]–[19] argued that instructional media alone do not influence learning outcomes, Kozma [20], [21] and Smith and Dillon [22] maintained that media characteristics can enhance learning when aligned with appropriate pedagogy. Regardless of this debate, the importance of systematic instructional design in technology-mediated environments remains widely recognized.

Online environments are particularly conducive to collaborative and project-based learning. Strategies such as case studies, debates, role-playing, and threaded discussions foster interaction and community building [23]. Research shows that students engaged in online PBL develop deeper content knowledge and higher-order problem-solving skills through collaborative discussion [24]. Furthermore, successful distance learning depends on establishing a community of learners in which knowledge is constructed individually and socially [25]–[28].

However, collaborative groups do not always function equally effectively. High-performing groups tend to demonstrate shared leadership, equitable task distribution, and strong task comprehension, whereas lower-performing groups may struggle despite teacher facilitation [29], [24].

1.1 Between-Group Collaboration

Between-group collaboration refers to structured interaction among students working in different project teams. Similar to Wenger's concept of communities of practice [30], such collaboration enables participants to share expertise, language, and tools. Without exposure to diverse perspectives, individual groups may face limitations in problem-solving capacity. Preliminary studies indicate that between-group collaboration in online environments enhances learning outcomes [31], [25]. This study aims to provide deeper insight into the processes and outcomes of project-based intergroup collaboration in online learning environments. The research questions were: (1) How does online collaboration between groups influence: a. The quality of collaborative discourse? b. The performance of group projects? (2) How do students perceive their experiences with online between-group collaboration?

2. METHOD

This study employed a mixed-method research design integrating both qualitative and quantitative data to obtain a more comprehensive understanding of the research problem. Collecting both types of data allows for deeper interpretation and triangulation of findings [39].

2.1 Participants and Context

Participants were drawn from two courses offered by the College of Education at a large research university. Both courses used online learning environments to support collaborative group learning. Case A involved 18 graduate students (14 female and 4 male) enrolled in an educational research course delivered primarily online. Two face-to-face sessions were held to address topics considered too complex for online delivery.

Case B consisted of 18 junior or senior undergraduate students and beginning graduate students (16 female) enrolled in an educational technology course conducted mainly face-to-face with online group assignments. Each class served as an illustrative case to examine how collaborative learning and between-group interaction influence learning processes and outcomes.

2.2 Data Collection

Data were collected over one semester and included:

- Transcripts of online group discussions
- Completed group projects
- Student responses to a Likert-scale attitude questionnaire

Students were informed that their online discussions would be monitored and included in project assessment. Consent for the use of their communication for research purposes was obtained at the end of the semester.

2.3 Discourse Analysis

All online discussions were analyzed to understand the nature and quality of group interaction. One challenge in studying collaboration is documenting individual contributions within a shared activity system [40]. The categorization of discourse followed established models of verbal interaction and content analysis [41], [42]. Interactions were classified into two major categories:

Task-related interactions

- (e.g., making suggestions, questioning ideas, accepting proposals)
- Socio-affective interactions
- (e.g., humor, encouragement, group building)
- Task-related interactions were further categorized according to levels of critical thinking [43].

Higher-level cognitive interactions included:

- Offering alternative suggestions
- Questioning ideas or positions
- Identifying limitations
- Expressing disagreement
- Providing cognitive elaboration or explanation
- Organizational or management statements

Lower-level cognitive interactions included:

- Declarative statements
- General agreement or praise

- Requests for clarification
- Simple clarification of details

The unit of analysis was determined by the meaning and purpose of each sentence in a message. A message unit could consist of multiple sentences expressing the same idea. To ensure coding reliability, two raters independently coded message samples. Initial agreement was 50%. After clarification and practice coding, inter-rater reliability exceeded 80%.

2.4 Project Evaluation

Group projects were evaluated using analytic rubrics aligned with course objectives. In the educational technology course, WebQuest design criteria were applied [44], [45]. Key evaluation components included:

- Motivational quality of the introduction
- Cognitive level of tasks
- Clarity of procedures
- Availability of resources
- Clarity of evaluation criteria

Each criterion included three competence levels: beginning, developing, and accomplished. Instructors assigned grades based on these rubrics. At mid-semester, mean project scores were calculated for each group. A class mean was then computed to categorize groups as:

- More Effective (ME) – above class mean
- Less Effective (LE) – below class mean

To ensure differences were not due to prior ability, midterm exam scores were compared. No significant differences were found between ME and LE groups in either class.

2.5 Attitude Questionnaire

Student perceptions of between-group collaboration were measured using a Likert-scale questionnaire adapted from SAGE [46]. Although the instrument contained multiple items on collaborative learning, only eight items focusing on motivation and learning in between-group collaboration were analyzed in this study. The questionnaire was administered at the end of the semester.

2.6 Implementation of Between-Group Collaboration

Students were randomly assigned to groups of two to four members at the beginning of the semester. Blackboard was used as the course management system for online collaboration. Each group had access to:

- A private discussion forum
- Virtual chat
- Assignment drop box

During the first half of the semester, students engaged in project-based collaborative learning within their small groups. At mid-semester, between-group collaboration was introduced in both classes.

1) Case A: Between-Group Mentoring

Initial analysis showed clear differences between ME and LE groups in both the quantity and quality of online discourse. ME groups demonstrated:

- Higher participation
- More balanced contribution
- Frequent supportive messages
- Organizational planning
- Alternative suggestions and solutions

LE groups tended to provide declarative statements, ask fewer questions, and show limited planning. Therefore, ME groups were paired with LE groups to provide mentoring. The three highest-performing groups were paired with lower-performing groups and granted access to each other's Blackboard discussion spaces. ME groups were expected to model higher-level interaction and provide constructive feedback. Three additional projects were completed during the second half of the semester.

2) Case B: Between-Group Project Review

In the educational technology course, between-group collaboration took the form of structured peer review. During the first half of the semester, project quality varied widely despite instructor feedback. Many students lacked experience in instructional design.

- During the second half of the semester:
- ME groups were paired with LE groups
- Open discussion forums were created
- Students were required to provide constructive feedback
- Students were encouraged to review all projects

The goals were to:

- Improve self-regulation
- Promote higher-order critical thinking
- Broaden perspectives
- Increase awareness of strengths and weaknesses
- To support effective implementation, instructors provided:
- Modeling of constructive feedback
- Evaluation rubrics
- Class discussions on quality design

3. RESULTS AND DISCUSSION

To answer the research questions, the attitude questionnaire, online discourse, and project performance data were analyzed. The following subsections present the results that correspond to each major question.

Case A: The Effects of Collaboration Between Groups on Project Processes and Performance Mentoring in Between Groups In the educational research course that was mostly taught online, mentoring between groups consisted of a more or less effective group joining the conversation of their partner group.

Analyses were conducted on the online dialogue sessions for collaboration that took place as two projects were completed. The second of three projects that were completed while working in small-group collaboration and the second of three projects that were completed while working in

between-group collaboration were selected for analysis for the purposes of this article. The analysis of the dialog sessions of the less effective (LE) and more effective (ME) groups revealed that the collaboration among the groups improved the performance of the less effective groups. The depth and quality of their dialogue as well as their project grades showed that the less effective groups performed better. When the groups engaged in small-group collaboration, there was a difference in the mean project grade between the groups that were less effective and the groups that were more effective ($M=86.67$, $SD=12.69$ for the LE groups); When they participated in the between-group partnering ($M = 93.17$, $SD = 5.85$ for the LE groups), there was little difference in the mean project grades ($M = 95.21$, $SD = 4.75$ for the ME groups); For the ME groups, $M = 94.83$, $SD = 4.30$).

The content analysis of the messages posted by each group yielded the data in Table 1. For each message category, a mean frequency across the three less effective and three more effective groups was calculated. Even though members of the partner group contributed to the discussions, only posts from members of the primary group are included in the data in Table I. The analysis showed that there was a lot of content and their message postings became more extensive. More specifically, the less successful groups provided a greater number of socio-affective comments, alternative suggestions, questioning ideas or positions on issues, disagreements, organizational statements, and higher cognitive task-related message units.

Postings that represent each type of message unit in project-based group collaboration are as follows:

- Providing Other Suggestions: My thought was to continue in the same direction as our standardized test. Therefore, one group receives treatment, and the other does not. Because we have two groups, a t test could be used.
- Questioning Positions and Ideas: I agree with you that all schools should receive the same amount of money. However, educational equality is not limited to this issue. Please suggest additional strategies for achieving educational equality for our students and their message postings became more extensive. More specifically, the less successful groups provided a greater number of socio-affective comments, alternative suggestions, questioning ideas or positions on issues, disagreements, organizational statements, and higher cognitive task-related message units.
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- Questioning Positions and Ideas: I agree with you that all schools should receive the same amount of money. However, educational equality is not limited to this issue. Please suggest additional strategies for achieving educational equality for our students.

3.1 Online Collaboration among Groups

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

Categories	Small-group project LE	Small-group project ME	Between-group project LE	Between-group project 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

Categories	Small-group project LE	Small-group project ME	Between-group project LE	Between-group project ME
Expressing disagreement	0.0	1.5	2.5	3.5
Providing cognitive elaboration/explanation	1.5	2.5	2.0	3.0
Organization/management	0.5	3.0	3.0	3.0
Total higher level	2.0	15.0	21.0	23.5
Task-related (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	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.

- Confirming Your Disagreement: Based on what I know, a hypothesis does not include the name of an instrument. That belongs in the section on methods."
- Offering Cognitive Explanation: Regarding your inquiry regarding math journals. From what I've seen, the teacher can use them however she or he wants. With more specific daily suggestions, I used them with my students to get them started."
- Management and organization: " Okay, let me describe what I believe needs to be done for this task. My suggestions for this task's steps are as follows: "If you agree with my suggestions, I can work on step one, and we can each complete one step."
- Making a Statement of Determination: We must generate fictitious scores for each student."
- Agreeing/Accepting: I share your opinion. I arrived at the same conclusion after reading the text."
- Asking for more information or clarification: I thought you might be aware of the math concept section's scoring since you gave the ITBS. Should we look it up somewhere, or do you know?
- Making Things Clear: " Regarding your inquiry regarding content validity, the STAR Reading Test actually measures reading ability.
- Personality type: It's encouraging to learn that someone else can speak Spanish. I appreciate your support because I am aware that I must continue the project.

Case B: Between-Group Project Review In the educational technology class that met twice a week, groups reviewed each other's instructional design products as part of between-group collaboration. Even though several strategies for guidance and scaffolding were used, it took some practice for all of the students to learn how to give and value effective peer feedback. For instance, during the initial project review experience between groups shortly after the midterm, one group complained that their partner group's criticisms were too harsh to be acceptable. All students gradually learned to give and value constructive feedback to one another and improved their projects as a result of openly discussing the issue in class and viewing some of the more balanced and tactful feedback provided by other groups. For the first and final projects, the mean frequency of message units for each feedback category provided by the more and less effective groups is shown in Table 2. Both more effective and less effective groups' members were able.

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

Categories	Between-group Project 1 LE	Between-group Project 1 ME	Between-group Project 2 LE	Between-group Project 2 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	17.0	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 determine, in accordance with the rubric, specific advantages and disadvantages of surface-level features for each project. In both of the activities involving collaboration between groups, the more productive groups provided a relatively higher frequency of feedback at a higher cognitive level, such as making suggestions, asking questions or pointing out limitations in ideas, and providing cognitive elaboration or explanation. In the subsequent activity, the less effective groups provided more higher-level feedback, particularly in the cognitive elaboration/explanation category, through practice and interaction with the more effective partner groups.

The message units that represent each type of feedback between groups are as follows:

- Making Observations: Telling the students precisely what you want them to include on their pamphlets might be helpful, in my opinion.
- Examining and identifying Ideas' Limitations: I thought the concept was clever. However, because the idea of a time capsule involves planning for the distant future, it may be difficult for fifth graders to complete this activity.
- Giving additional details or explanations: You need to provide more information about what to look for and how the searches should be carried out.

Based on the review of the group projects, there were a few noticeable changes in the revised group projects. One change was that almost all groups made significant improvements in response to their partner groups' suggestions or limitations. The modeling effects of reviewing and recognizing the particular strengths of other projects were another change. Groups that weren't as good used some of the tactics used by groups that were, and as a result, their own projects got better. For instance, in one project, a less effective group gave unclear instructions for activity processes. The less effective group appeared to adopt a similar approach in their revision, which significantly improved the quality of their project, after observing the clear steps provided by the use of a single worksheet for each activity in the project of their partner group. In the most recent between-group project, the less effective and more effective groups' mean project grades significantly improved over their draft versions ($M = 79.21$, $SD = 5.57$ for the LE groups; From the initial versions ($M = 86.71$, $SD = 2.72$ for the ME groups) to the final versions ($M = 89.63$, $SD = 2.78$ for the LE groups; For the ME groups, $M = 93.71$, $SD = 2.46$).

- This age group may occasionally search too broadly

- Identifying Particular Advantages: I was intrigued by the introduction and eager to continue reading to find out what came next. It also provided background information to help the student understand how important bugs are to us and our lives.
- Identifying Specific Limitations: It was stated, but not very clearly, how students will be evaluated.
- Overall Appreciation and Acceptance: The activity you created was very enjoyable for me, and I'm sure students in fifth grade would agree.

3.2 Perceptions of Student Collaboration in Groups

From the attitude questionnaire that was administered at the conclusion of the semester in both classes, a summary of student perceptions of their experiences with between-group collaborative learning is presented in Table 3. In general, students in both classes agreed that collaboration among groups had positive cognitive and motivational effects.

On a 5-point Likert scale, the four items' average ratings for perceived cognitive benefits ranged from 3.39 to 4.07. The item with the highest rating was that the opportunity to examine the projects of other groups provided participants with additional perspectives on project execution. In each class, the mean ratings for both kinds of groups were higher than 4.00. The students also believed that reviewing and giving feedback to each other's groups helped them identify their own projects' strengths and weaknesses. The average group rating ranged from 3.71 to 4.00. The fact that there were relatively small standard deviations for both items indicates that students' perceptions were fairly consistent. The average rating for each of the four items was between 3.29 and 3.65, and it related to the perceived motivational benefits of collaboration between groups. The initial two

Items asked students if the activities for group collaboration made them work harder. The mean ratings were low for all groups and had relatively large standard deviations, indicating that some students agreed that they worked harder while others disagreed. The last students may have been under the impression that they were already working hard. The majority of students thought it was rewarding and encouraging to receive positive feedback from other groups. The students gave the item that receiving feedback from students in other groups was not a waste of time the highest and most consistent ratings out of the four motivational items. This indicates that students believed that the activities that involved collaboration between groups were beneficial to them.

The above cognitive and motivational results seemed to indicate that the students thought that the activities that involved collaboration between groups were a good use of their time, broadened their perspectives, and helped them understand the strengths and weaknesses of both their own projects and those of other groups.

2. CONCLUSION

This study examined how collaboration between groups enhanced the performance of collaborative learning teams engaged in project-based learning tasks and supported the coconstruction of knowledge. Findings from two case studies one focusing on intergroup mentoring and the other on intergroup project review indicated that both strategies were positively perceived by students and contributed to improvements in collaborative learning skills, the quality of knowledge construction reflected in online discourse, and overall project performance. These improvements were particularly evident among students in less effective groups. The findings provide insight into how higher-education students participate in computer-supported collaborative environments and demonstrate that structured mentoring or guided peer review across groups can strengthen small-group project-based learning.

Consistent with the concept of communities of practice [47], intergroup collaboration enabled project teams to exchange ideas, strategies, and experiences. Although small groups working on complex projects benefit from diverse perspectives and shared responsibility, access to knowledge and resources is often limited to members within a single group. Without prior experience, groups may feel isolated and encounter challenges when attempting to solve problems independently. Moreover, focusing on only one project may limit exposure to varied real-world issues. Establishing collaborative learning communities across groups extends learning beyond individual teams and broadens students' perspectives.

A self-regulation based feedback model for effective e-learning emphasizes that students often fail to achieve higher-level learning goals due to an unclear understanding of desired outcomes [48]. The model highlights both self-feedback and peer feedback as important learning resources. Through peer collaboration and constructive feedback, students develop clearer understandings of goals and effective strategies for achieving them. The findings of this study support this perspective: reviewing other groups' online drafts expanded students' perspectives, helped them identify strengths and weaknesses in their own work, and fostered critical thinking and self-regulation. Providing feedback across groups also strengthened students' ability to evaluate others' work an essential professional competency for educators and facilitated the transfer of conceptual understanding to practical application.

This study contributes to the growing body of research on instructional strategies in technology-supported higher education environments. The results indicate that structured intergroup collaboration can improve both project outcomes and the collaborative processes within group work. However, the exploratory nature of the study and its relatively small sample size limit the generalizability of the findings. For instance, graduate students enrolled in online courses may benefit more from intergroup mentoring approaches than other student populations.

Further research is needed to examine the effects of different intergroup collaboration strategies across varied contexts and student characteristics. Notably, students in both case studies reported greater cognitive benefits than motivational benefits from intergroup collaboration. Although most students agreed that collaborative activities between groups were a productive use of time, their perceptions of increased motivation varied. Previous research suggests that peer interaction can encourage less active participants to engage more actively in online discussions [49], a finding supported by the present study. Future research should therefore explore the motivational effects of intergroup collaborative learning in greater depth.

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