



Effectiveness of Collaborative Learning in a CM Flipped Online Course: A Case Study

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The collaborative learning has been used for Construction Management (CM) courses to enhance students' learning. Few existing studies reported the effectiveness of collaborative learning in terms of assessment score in CM online courses: existing literature found the effectiveness of collaborative learning in CM courses based on students' perception. This research aimed to study the effectiveness of collaborative learning in an online CM course in two ways: in terms of 1) student's assessment score and 2) students' perception. Students in a CM course taught by the first author were grouped into two: the experimental group with collaborative learning experience and the control group without collaborative learning experience. Their assessment scores and perceptions on collaborative learning experience were examined in this study. The test scores and students' response to the questionnaire survey showed a mixed result. While the students in the experimental group perceived that collaborative learning was helpful in their learning, there was no significant difference in the assessment scores between the two groups. The finding from this study can help CM educators by providing a quantitative and qualitative study on the effectiveness of collaborative learning in online CM courses.

Key Words: Collaborative Learning, Synchronous Online Class, Flipped Classroom

Introduction

Collaborative learning can be defined as “an instructional method in which students at various performance levels work together in small groups towards a common academic goal” (Gokhale, 1995). Many researchers and educators have reported that collaborative learning can be beneficial to students in many aspects such as students' knowledge construction and building team management skills. Thus, collaborative learning has been widely used across face-to-face, online and hybrid courses (Lee et al., 2006). Also, collaborative learning has been adopted and used for construction education (Chan and Sher, 2014).

The remote learning approach has been adopted and employed for construction education, specifically during the COVID-19 pandemic. Students can take lessons, complete assignments, and work together with their classmates through online tools such as a learning management system (LMS) without physically being in a classroom. However, the remote course delivery approach has several limitations such as interaction between students, between student and teacher, and collaboration for students'

group assignments (Sobko et al. 2019; Adhiikari et al., 2021). Advancement in information technology has allowed students in online classes to communicate and collaborate with their peers more efficiently in diverse formats in online classes such as through a LMS discussion forum, email, video conference, etc. Synchronous online teaching became available due to advancement in information technology as well; students can join a virtual classroom and take lessons without being in a classroom in-person.

The authors' institution required that all the courses should be delivered remotely under the COVID-19 pandemic, specifically since the second half of the Spring 2020 semester. The first author transformed his courses abruptly from face-to-face format to the online format in the semester. The lectures were pre-recorded and shared through a LMS, and the students were required to finish assignments remotely. All the homework assignments in the courses were done individually and remotely. The courses were taught in an asynchronous approach. The students in the courses barely interacted with their classmates in the asynchronous format of course delivery, and the author received negative feedback from students on the missed learning components. Thus, the first author changed the course delivery method from asynchronous online to synchronous online for his courses in the Fall 2020 semester.

While benefits of collaborative learning in higher education have been studied, few studies found these benefits of collaborative learning on students' learning in synchronous online classes for construction education. This research aimed to explore the effectiveness of the collaborative learning approach on students' learning in the first author's synchronous online construction course.

Literature Review

Benefits of Collaborative Learning

Collaborative learning allows students to work together at various performance levels (Gokhale, 1995) and enables students to link their experiences with those of their peers (McNamara and Brown, 2008). It has been reported that the collaborative learning approach is a more effective teaching method than the traditional teaching method (Coffey and Clarke, 2021). In addition, benefits of the collaborative learning approach have been reported in diverse aspects: improvement in academic achievement (Stump et al., 2011), stronger learner satisfaction (Springer et al., 1999), effective delivery of generic skills (Johnson and Johnson, 2009), improved interpersonal skills (Johnson and Johnson, 2009), development of better critical thinking skill (Palloff and Pratt 2005), development of a sense of community (Palloff and Pratt 2005), and development of social skills needed for future professional work (Scager et al. 2016).

Also, other existing literature reported that the improvement in students' learning through the collaborative learning approach could be obtained through: communication and knowledge exchange (Chiong and Jovanovich, 2012), discussion with their peers and faculty (Goold et al., 2006), high quality social interaction and engagement between students (Visschers-Pleijers et al., 2006), and fostering a diversity of thought from other students (Laux et al., 2016-1)

Collaborative Learning in Online Classes

Due to advancement in information technology, collaborative learning has been increasingly used for online courses (Lee et al., 2006). The ease to share what is created and communicated online made the

collaboration in online courses more affordable (Sobko et al. 2019). Additionally, several other researchers reported advantages of online collaborative learning compared to face-to-face collaborative learning: task completion and effectiveness of work (Morsi and Assem, 2021), more cognitive load and collaboration (NireLan et al., 2019), and higher level of equity in students' participation in class activities (Fowler, 2014). Due to the benefits of collaborative remote teaching, Adhiikari et al. (2021) recommended more collaborative activities in CM online courses, specifically during the pandemic.

Online courses can be taught synchronously or asynchronously. In a synchronous online class, students are required to join a class meeting at a specified time through an online tool such as Zoom and complete real-time class online. On the other hand, students in an asynchronous online class can finish all required learning tasks at their convenient time. Online synchronous learning involves a real-time, instructor-led learning environment where students can interact with their instructor(s) and other participants at the same time. Benefits of synchronous learning were identified as increased student focus on tasks (Chen and You, 2007), a larger sense of participation by students (Mabrito, 2006), better task competition rates by students and better control of the interactions in class by teachers (Hrastinski, 2010).

However, the synchronous online class may be more teacher oriented (Murphy et al., 2011), thus, diverse class activities are recommended to broaden the scope of communication and interaction between students (Perveen, 2016). One solution to more students' interaction and active learning opportunities is to "flip" the classroom. By moving direct instruction from the group learning space (class time) to individual learning space (pre-class assignment), more class time can be used for a dynamic and interactive learning environment (The Flipped Learning Network, 2014).

Effectiveness of Collaborative Learning in Synchronous CM Online Classes

Effectiveness of collaboration on students' learning has been of interest to researchers and teachers for construction education. Chan and Sher (2014) studied benefits of collaborative learning in Architecture-Engineering-Construction (AEC) courses and identified that the collaborative learning approach could provide enhanced academic knowledge and general skill. However, the result was based on students' perception through a questionnaire survey, and the AEC courses in which the effectiveness of the collaborative learning was studied were not in an online format. Dong and Guo (2013) reported that the collaborative learning methods in their online courses led to higher satisfaction in students' learning from two questionnaire surveys administered pre-collaboration and post-collaboration. Zheng et al. (2018) studied the effectiveness of the collaborative learning in their non-online courses through comparison of test scores between two groups and concluded that the collaborative learning increased students' knowledge. However, the collaborative learning activity in their study was limited to discussion through an online discussion board in the learning management system. Laux et al. (2016-2) reported that the collaborative learning approach impacted students' learning positively in a non-online class. Their conclusion was also based on students' perception, not on the direct assessment of students' learning outcome.

Existing literature includes only a few studies on effectiveness of collaboration on students' learning in a synchronous online course. Akarasriworn and Ku (2013) used an online synchronous video conferencing application which includes functions of video, audio, chatting, and whiteboard in an online class and concluded the tool promoted students' knowledge construction. Sobko et al. (2019) studied the effectiveness of collaboration in their online class where a synchronous video conference application was used for discussion and reported that students' knowledge construction was improved by the synchronous engagement tool. However, the findings from these studies are based on students'

perception through questionnaire surveys, not based on direct assessment of students' learning outcome.

While it has been reported that online collaboration enhances students' learning achievement, few empirical studies have examined the effectiveness of synchronously collaborative learning approach on students' learning through direct assessment of students' learning outcome in CM courses.

Research Question

The objective of this research is to explore benefits of collaborative learning on students' learning in a synchronous online CM class. Specifically, this study aims to find the answer to the question, *how effective is collaborative learning on students' learning in a synchronous online CM class?* The research question is divided into the following sub-questions to fulfill the research objective:

- 1) How does the collaborative learning approach affect students' test scores before and after the collaborative learning experience?
- 2) How do students perceive the effectiveness of collaboration on their learning?

Methodology

The Construction Scheduling course which was taught by the first author in the Fall 2020 semester was transformed to a "flipped classroom" to allow more collaboration and real-time feedback in a synchronous online format. The "flipped" format in the course includes the following key features:

- 1) Lecture videos and online quizzes before class: short lecture videos (maximum time was 15 minutes) were recorded to introduce a new topic to students and students were required to watch the videos before the class. They were also requested to take online quizzes after watching the lecture videos. The main purpose of the pre-class online quizzes was to encourage the students to study the content before the class.
- 2) Quick review session and class activities during class: at the beginning of each class, the course instructor reviewed the lecture for the class quickly, and student were provided with two types of class activities as followings.
 - Instructor-guided problem solving: the course instructor explained how to apply the knowledge which was introduced in the lecture video(s) in a real-world problem.
 - Student-led work example problem: After the instructor-guided problem solving, another real-world problem was assigned to students. They were asked to turn in the assignment near the end of the class. The student-led work problems were typically a more complex application of the basic content so that students' knowledge could be expanded or enhanced.

Several tools and applications were used to support the synchronous online format and synchronous collaboration in the course: a learning management system for sharing lecture videos, quizzes, in-class work problems, and students' grades, a video conferencing application (Zoom) for real-time lecture and communication including the *Breakout Room* function, *Microsoft Class Notebook* for instant feedback of students' in-class problem solving, an online whiteboard application (*Mural*) for presentation of solutions to complexed problems such as network diagrams for a construction

schedule, and *Citrix Remote Desktop and Virtual Apps* for the access to the scheduling software (*Microsoft Project*).

Measurement of the Effectiveness of the Collaboration through Two Student Groups

To measure the effectiveness of collaborative learning in a synchronous online CM class (the research question #1), students in the course were divided into two groups. One group was asked to complete all the class assignments (or in-class problem solving) with collaboration (the experimental group), and the students in the other group were asked to complete all the in-class assignments individually. Change in each student's assessment scores before and after in-class activities (or assignments) were statistically compared through a student's t-test.

The course had two sections in Fall 2020. The first section (Section 01) was the experimental group, and the other section (Section 02) was treated as the control group. The students in the experimental group were required to form a group of two students and complete all in-class assignments (or activities). To help students in the Section 01 stay accountable for their group work, the students were required to complete and submit a peer-evaluation for each assignment as suggested by Kim et al. (2008). A total of 13 pre-class online quizzes were assigned to the students in both groups. Table 1 compares the required work between the two groups.

Table 1

Required student's work

	Before class	During class	Assessment
Section 01: with collaboration	13 Individual pre-class assignments for both sections	Collaborative in-class problem solving	Individual exam
Section 02: without collaboration		Individual in-class problem solving	

Students in both the experimental and control groups were required to take pre-class online quizzes individually before the in-class learning activities and an individual exam at the end of the semester. This research aimed to explore how the collaborative learning activities in the experimental group would affect students' learning. The effectiveness of the collaborative learning was to be assessed through the change in assessment scores (pre-class online quiz score and exam score after the collaboration). Then, the changes in the two student groups were compared if there is any significant difference.

The students in the course were required to take total 13 pre-class online quizzes. The average score for the pre-class online quizzes was calculated. While the pre-class online quizzes typically were less than 10 simple questions, the exam was the only test which counted for 25 percent of a student's final grade and included questions about all the topics learned through the semester. Thus, it was expected that a student's exam score would be lower than the pre-class online quiz score for the student. The change between the two scores is calculated as *exam score – pre-class online quiz score* in this research. The null hypothesis was that there would be no significant difference in the change between the two scores between the two groups.

Students' Perception on Collaborative Learning

In addition to quantitative measurement of the effectiveness of the collaborative learning on students' learning (the research question #1), a questionnaire survey was administered to find how students perceived the collaborative learning experience in the course (the research question #2) only to the students in the experimental group. The only question in the survey was how students agree to the statement, *Collaboration has been helpful for me to understand/expand the key concepts and to solve the problems in the in-class assignments*. The question was asked to only the students in the experimental group through the *Microsoft Forms* at the end of the semester.

Results

There were 26 students enrolled in the Section 01 (the experimental group), and 23 students enrolled in the Section 02 (the control group). All the scores for both the pre-class online quizzes and the exam were collected and graded through the course learning management system. Students' response to the survey question were collected through the *Microsoft Forms*. A total of 25 responses out of the 26 enrolled students in the experimental group were collected and 23 responses were collected in the control group.

Effectiveness of the Collaboration on Students' Learning through Exam Score

The Figure 1 below shows the average scores for pre-class online quizzes and the average exam scores for the two student groups. In both groups the (average) exam scores were lower than those in the pre-class quizzes.

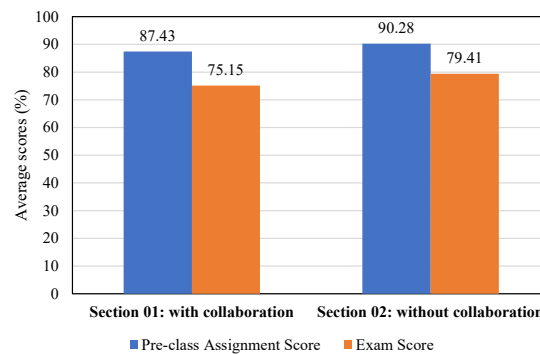


Figure 1: Assessment results between the two groups.

The two average scores in each class section were investigated to see whether there was a significant difference between the two sections through a student t-test. The average pre-class assignment scores (87.43% in the experimental group and 90.28% in the control group) are not statistically different. Also, the average exam scores between the two groups (75.15% in the experimental group and 79.41% in the control group) are not significantly different.

The changes between the exam score and pre-class online quiz score [*exam score- pre-class online quiz score*] in the two class sections were analyzed through a student t-test. The null hypothesis was that there is no significant difference in the change between the two scores between the two groups. The p-value is greater than the alpha value (0.05), so the null hypothesis cannot be rejected: the

changes between the exam score (average score) and the pre-class quiz score (average score) between the two student groups are not significantly different. The results indicate that the collaborative learning activities in the course were not more effective on students' learning than the individual learning approach.

Students' Perception on the Effectiveness of the Collaborative Learning

The Figure 2 shows students' responses to the survey question about helpfulness of the collaborative learning activities in the class (the experimental group). 80% of the students perceived that the collaborative learning approach was helpful (52% for "Strongly Agree" and 28% for "Somewhat Agree").

Collaboration has been helpful for me to understand/expand the key concepts and to solve the problems in the in-class assignments.

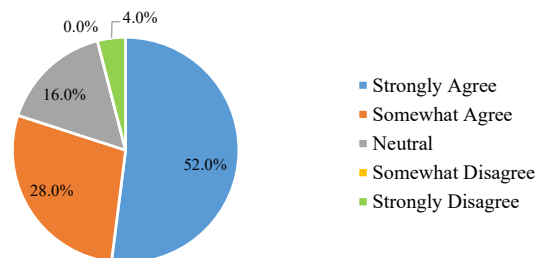


Figure 2: Students' response on degree of helpfulness of the collaboration.

Discussion

The students' assessment scores and their answers to the questionnaire survey in this study show mixed results. While students perceived that collaborative learning was effective on their learning, the assessment scores (for both exam score and online quiz scores) show that the collaborative learning was not more effective than individual learning approach. One of the limitations in this research is the small sample size, and this limitation may have caused the mixed results.

Conclusions

The collaborative learning approach has many advantages such as improved academic performance and stronger student satisfaction, and this approach is recommended for active learning for construction education. Recently, the online course delivery method has become more popular due to advancement in information technology. Also, online course delivery method was requested during the COVID-19 pandemic, specifically in the Spring 2020 semester. In an online course delivery approach, collaborative learning activities were recommended to enhance the students' learning. Advancement in information technology allowed more diverse formats of real-time collaborative learning experiences in synchronous online class. However, few existing literature studied the effectiveness of collaborative learning experience on students' learning in synchronous online CM courses, specifically directly measured from assessment of student learning outcomes. Thus, this

study aimed to investigate the effectiveness of collaborative learning on students' learning in a synchronous online CM course through a case study. One CM course at the authors' institution was transformed to a format of synchronous online flipped class in the Fall 2020 semester for the case study. The students in one section of the course were taught with collaborative learning activities (the experimental group), while the students in the other section finished class activities without collaboration (the control group). The change in each student's assessment score before and after the class activities was compared between the two student groups, and it was concluded that the collaborative learning approach was not more effective than the typical individual learning approach. However, students who finished the course with the collaborative learning activities perceived that the collaboration in the class was helpful. These mixed results need future research with large samples. This finding can be helpful to construction educators because this is the first research on effectiveness of collaborative learning which was assessed directly from students' tests in a synchronous online CM course.

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