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Flipped Classrooms and Peer-to-Peer Learning in a Construction Management Course

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This paper presents a case study of the implementation of a combined peer-to-peer learning and flipped classroom approach in a course within a baccalaureate degree program in Construction Project Management. In a flipped classroom, students review the learning materials before class, complete lower-level cognitive tasks outside of the classroom, and engage in higher-level cognitive tasks during class time. While there are numerous advantages to flipping the classroom compared to traditional teaching, the strategy becomes ineffective if students cannot complete the assigned tasks before class and lack motivation to participate in higher-level learning during the class. To ensure motivation and continuous engagement, a combination of strategies was employed, including peer-to-peer learning and teaching, granting credits for classroom participation and peer evaluation, and establishing milestones for continuous evaluation of outputs. Over the years, the percentage of students who agreed that the course's delivery method provided opportunities for active participation in discussions and collaborative activities increased from 80% to 100%. Similarly, the percentage of students who completed the readings and homework on time increased from 85% to 100%.

Key Words: Flipped classrooms, Peer-to-peer learning, Construction Management, Text analysis

Introduction

The development in understanding of what constitutes learning and how learning is acquired has led to experimentation of many innovative teaching practices. One such practice involves making learners active participants in the learning process. As the traditional approach of an instructor transmitting the knowledge as a ‘sage on the stage’ has many disadvantages, educators are experimenting with novel ideas where learners actively engage with the content and instructors facilitate the learning as a ‘guide on the side’ (King, 1993). The underpinning of this approach has its roots in the constructivist theory of learning. According to the theory, individual learners process information to create their own knowledge based on their experience and existing knowledge. In contrast to traditional classrooms where knowledge is passed by a teacher to students in a package, “the constructivist model places students at the center of the process actively participating in thinking and discussing ideas while making meaning for themselves” (King, 1993, p. 30). Alongside advancements in understanding the

theory of learning, the evolution of technology and the availability of open educational resources have also been instrumental in experimenting with teaching models where learners take center stage in the learning process.

One such model of a student-centered approach in teaching is the flipped classrooms, also termed the "Inverted Classroom", as described by Lage et al. (2000). According to Lage et al. (2000), the activities that traditionally take place inside the classroom are completed outside of the classroom and vice versa in such inverted classrooms. Mazur (2009) introduces a modified version of the flipped classrooms known as "Peer Instruction", in which students are required to review class materials before attending classes and the class time is then dedicated to discussing and assimilating this information (Mazur, 2009). In this approach, it becomes a student's responsibility to gather information and complete lower-level cognitive tasks, such as understanding and remembering before class. The class time is then utilized for "discussions, peer interactions, and time to assimilate and think" (Mazur, 2009, p.51). As classrooms can be flipped in various ways and different strategies, depending on the circumstances, can be employed to engage learners, there is no single definition or a standard set of criteria that captures the entire spectrum of flipped classrooms. However, students reviewing learning materials in their own time before class and using in-class time for higher level discussions can be considered as two fundamental elements of a flipped classroom. Müller and Wulf (2021) also suggest a similar approach for a flipped classroom where learners obtain and build knowledge beforehand, allowing classroom sessions to focus on interactive discussions and practical applications. Although flipped classrooms are ideal for ensuring active engagement of learners and making learners own their learning process, successful implementation of the strategy presents many issues and challenges. After reviewing various publications of the flipped classrooms, Zainuddin et al. (2019) have summarized some issues, such as effectiveness and learners' motivation, related to this approach. According to them, "flipped-class instruction has no significant effects on students' learning as compared to conventional instruction" (Zainuddin et al. 2019, p. 79). Another issue is lack of motivation among students for prior preparation. In a study done among a group of secondary school students, Tse et al. (2019) found that students in a video-based flipped class exhibited significantly lower motivation for subject reading, including reduced curiosity, perceived importance and compliance with assigned readings.

As success of a flipped classroom hinges on students' active participation in higher-level cognitive tasks during class, an instructor must ensure that students review assigned materials and arrive prepared. Unprepared students may otherwise lose interest inside the classroom, remain disengaged in learning and fall behind in the course. In order to motivate students for prior reading, an assignment-based model, such as proposed by Walvoord and Anderson (2001), can be implemented. In this model, students study assigned materials beforehand and bring, for example, a written response during class, earning credit for their preparedness. This process facilitates revising and rewriting work during class, promoting the application of information and higher-level of cognitive engagement during class (Walvoord and Anderson, 2001). As flipping a classroom requires a lot of work from students prior to the class, the strategy will be ineffective or even counterproductive if students are not motivated to go over the assigned materials and are not prepared for the class. Therefore, additional measures such as giving credits for out of class learning are required to make the flipped classrooms effective. As such, Brame (2013) considers four key elements of the flipped classrooms: students' exposure to the learning materials prior to class; incentives to come prepared; mechanism to assess learning; and in-class activities on higher-level cognitive tasks.

Along with motivating learners to come prepared for class, another aspect that can be integrated into the flipped classroom is peer-to-peer learning and teaching. The flipped classrooms, when implemented with such modifications, provide an opportunity for information sharing among the

peers and peer teachings both inside and outside of the classroom. Peer teachings have been implemented by teachers at least from the 60s (Whitman and Fife, 1988) and could have been in use even at the time of Aristotle as noted by Rodriguez (2012). As Whitman and Fife (1988) have mentioned, the impetus for engaging students to teach their peers arose as learners played a passive role during lectures otherwise. Allowing students to teach one another enables them to engage more actively with the content and take ownership of their learning process.

On one hand, peer-to-peer learning can happen in a flipped classroom while the learners work in a small group outside the classroom, focusing on preparing for low-level cognitive tasks. The same learners, on the other hand, can share the knowledge they have acquired with other peers as knowledgeable peers. The flipped classrooms combined with peer-to-peer teaching also becomes a platform for flipped learning which is the "concept of students serving as teachers to instruct, and learn from, their classmates" (Sterman, 2015). Peer teaching, according to Velez et al. (2011), synthesizes otherwise antagonistic theories of Piaget and Vygotsky as "peer teachers serve the role of the more knowledgeable peer, while engaging in peer-to-peer instruction" (p. 41). According to Piaget's theory of cognitive development (such as in Palincsar, 1998; Velez et al., 2011) learning happens through social interactions with peers as the imbalance between a learner's exiting knowledge and experience gained from interaction with peers leads the learner to acquire new knowledge. As Palincsar (1998) argues, "contradiction between the learner's existing understanding and what the learner experiences gives rise to disequilibration, which, in turn, leads the learner to question his or her beliefs and to try out new ideas". In contrast to Piaget's emphasis on learning from peers, Vygotsk's sociocultural theory of cognitive development puts an emphasis on learning from co-peers and from a more capable or knowledgeable individual (Hogan & Tudge, 1999 as cited in Velez et al., 2011). Fernández et al. (2018) have discussed and analyzed a similar strategy of combining the flipped classrooms with peer-to-peer learning and teaching as one of the four types of flipped classrooms. According their suggested strategy, students create content around a concept and explain it to their classmates. The resources created by students can then be consulted by other students and can be used by the instructor for evaluation purposes (Fernández et al., 2018).

Against this background, this paper presents a case study of implementation of flipped learning in a course in a baccalaureate degree program in Construction Project Management (CPM). The implementation strategy, used continuously for three years, combines a flipped classroom with peer-to-peer learning and teaching. The research questions that steered the development and evolution of this implementation strategy are as follows.

- Do learners have enough background knowledge to complete low-level cognitive tasks outside the classrooms?
- How can learners be motivated to come prepared for class?
- What measures can be implemented to consistently engage learners throughout the course?

Theoretical model

The flipped learning model in this study uses a model, illustrated in Figure 1, incorporates a combination of flipped classrooms combined with co-peers learning and teaching. In this model, students collaborate in a small group of peers to review assigned learning resources outside the classroom. During this phase, students receive new information from learning resources and exchange information with each other to acquire new knowledge. Subsequently, students share this new knowledge as knowledgeable individuals to their other peers inside the classroom (Figure 1). Instructors also act as knowledgeable individuals and facilitate the completion of higher-level

cognitive tasks inside the classroom. During this phase also, students engage in information sharing and exchanges as co-peers, integrating peer-to-peer learning into the acquisition of new knowledge within the classroom. Upon completing these learning activities, learners attain new knowledge, and this iterative process continues until all the learning goals are completed".

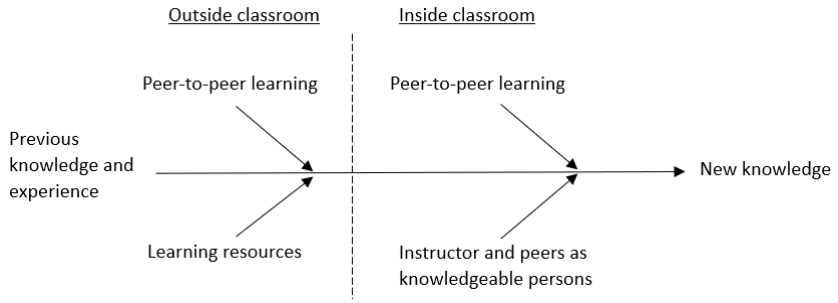

Figure 1. Model of flipped learning which combines the flipped classrooms and peer-to-peer learning and teaching

Methodology

The case presented in this paper is based on the implementation of the flipped classroom approach over three consecutive years in the International Construction Project Management (ICPM) course. The course is a core-course taken by fourth-year students in a bachelor's degree CPM program. Before flipping the class, a study was conducted to analyze the learning outcomes (LOCs) of the course in comparison to other subjects in the program. This analysis aimed to ensure that students taking the course have enough background on the subject matter to complete the lower-level cognitive tasks outside the classroom. The outcomes of this analysis are discussed in the next section. This section outlines the stepwise process adopted to implement the model, shown in Figure 1, in the course.

The stepwise process is presented in Figure 2. The process with the instructor providing an explanation in class about the subject, modality of the class, expectations, and evaluations. The first session is also an opportunity for students to get to know each other and form a group of 3-4 students. Each group reviews the course outline and prepares a brief summary of one LOC to share in the class. At the end of the class, each group is assigned three LOCs out of the 12 LOCs within the course. Each group then works outside the classroom to prepare a presentation for one of the assigned LOCs and two reports for the remaining two LOCs. In the subsequent stage, each group shares the reports and presentation slides to the class and explains their presentation to the class which is video recorded. Every week one group explains their presentation, and the content is discussed inside the classroom. Following completion of the students' work, the instructor supplements the content, and the class engages in higher level of cognitive tasks and application in practical scenarios. The presentations and slide decks are evaluated by students other than the presenters. Additionally, the resources shared by the students are stored on an internal blogging site, accessible as a reference for anyone taking the course. The implementation is planned in such a way that each LOC has at least one presentation slide deck, one video narrating the slides, and two reports submitted by different groups.

In addition to the evaluation of the presentation submitted by the students, the instructor also evaluates all the outputs, and these evaluations contribute to each individual student's final grade. Once all the learning outcomes are covered by the groups and instructor, students proceed to complete

a term project and authentic assessments, for which they can refer to the content created by the groups.

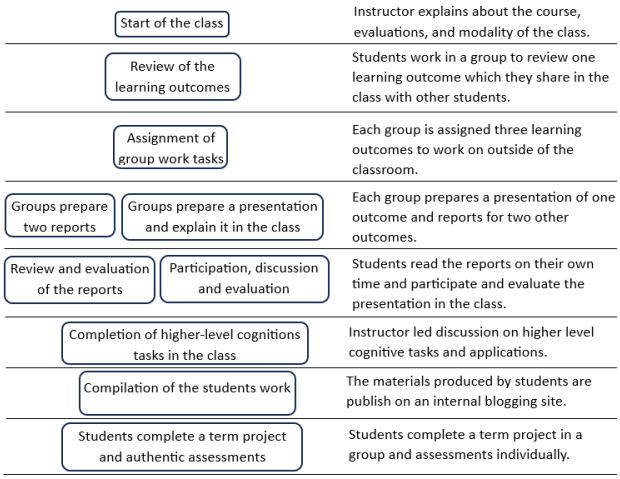

Figure 2. Steps in application of the flipped classrooms and peer-to-peer learning

Analysis of prior exposure to the content

As mentioned above, learners require prior knowledge of the content to have an effective engagement with the learning materials outside the classroom. Typically, students enroll in this course after completing a minimum of 600 hours of internship in the construction industry. This course being a final year course, students come into the class with significant background in and knowledge of introductory-level construction and project management courses. Prior to implementing the flipped classrooms approach, the instructor reviewed course outlines of the ICPM course with those of other courses in the program.

The course outlines in this program typically contain around 8-12 LOCs in each course, with each LOC further detailed into 5-7 learning objectives (LOBs). In order to assess the similarity of the ICPM course with other subjects, a text analysis of the outlines of all the subjects required to complete the program was conducted using an open-source text analytics tool called Orange. The resulting dendrogram from the text analytics is shown in Figure 3. A dendrogram is a plot that visualizes similarity among a group of entities, such as texts. As seen in the lower end of the dendrogram in Figure 3, ICPM, which is a fourth-year course, appears clustered with Introduction to Construction Project Management, which is a first-year course. These two courses, which are in cluster C4, have more similarity to each other compared to the courses, such as Project Cost Estimation, in cluster C3. The proximity of clusters C3 and C4 suggests that the courses in these clusters have more similarity compared to Statistics, for example, located in cluster C1 at the top of the plot.

A higher degree of similarity between the fourth year ICPM course and a first-year course implies that students enrolled in ICPM already possess some exposure to its content. Moreover, the content of ICPM exhibits a degree of similarity with the courses grouped in cluster C3, most of which students have also previously taken in prior semesters. This analysis suggests that students are capable of completing lower-level cognitive tasks independently outside the classroom, allowing for more

effective utilization of class time for higher-level cognitive tasks. This outcome is presented to the class on the first day and subsequently discussed with the students, after which they work in groups on the course outline, as described in the methodology section and depicted in Figure 2.

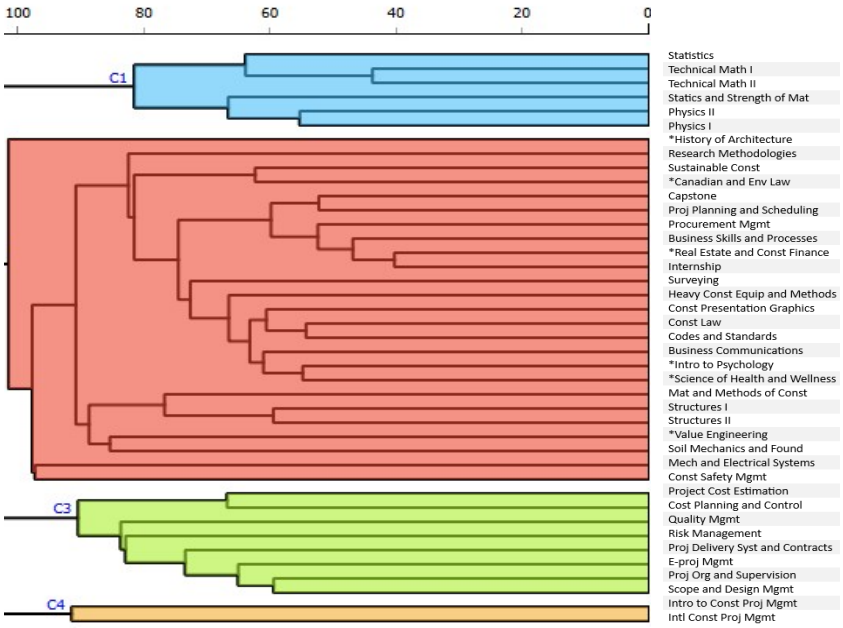

Figure 3. A dendrogram plot from text analytics of course outlines of all four-year courses. International Construction Project Management is seen at the bottom cluster (C4) along with Introduction to Construction Project Management. * *Indicates an elective course.*

Peer-to-peer learning and peer teaching

At the beginning of the class, the instructor explains the course outline, main references, expected activities, timelines, and evaluation scheme to the students. As a first activity, students form a group of 3-4 students and each group reviews one LOC and associated LOBs of the course. From this exercise, students produce either a brief presentation or a report encompassing a statement paraphrasing the expected learning, a summary of key issues found searching online resources, and their perspective on how the LOC aligns within the overall context of the course. At the end of the class, each group shares their work in the class. The instructor summarizes the activity by explaining the students about the sentence structure of a learning objective, different levels of cognitive tasks, Bloom's taxonomy, relationship between this course with previous courses, and the structure of the flipped classroom. The exercise not only familiarizes students with the course but also reinforces their proficiency in writing objective statements.

In the subsequent phase (Figure 2), each group is assigned one LOC for which they are required to develop a detailed presentation covering each LOB, and two additional LOCs for which they are required to prepare a report for each LOC. Groups collaborate outside of class hours, referencing documents listed in the course outline and other online resources. Each group presents their work on a designated date and time, followed by participation from classmates in a discussion. The presentation must incorporate a minimum of five objective questions related to their content. Upon conclusion of

the presentation, classmates respond to these questions, evaluate the presentation, and submit at least five key takeaways derived from it. Not only are peers involved in evaluating each other's presentations, but each student is also expected to actively participate in class, assess the presentation, and submit their own key takeaways. Each student's involvement and completion of these activities contribute towards their final grade, motivating their attendance and active engagement within the classroom. Further elaboration on the overall evaluation scheme is provided in the following section. Subsequently, the slides and video recordings of each group's presentation are shared within the class via an internal blogging site. Throughout the semester, students have access to these resources for reference and review. Post-presentation, the instructor prepares slides covering any overlooked aspects of the LOC and LOBs from the group's work, incorporating higher-level cognitive tasks. This content from the instructor is then shared and discussed in the subsequent class.

Evaluation schemes

As discussed earlier, two primary challenges are anticipated in implementing the flipped classroom. One is ensuring students' motivation to learn the assigned content and arrive prepared for class. The second challenge involves maintaining continuous engagement among students and motivating them to tackle higher-level cognitive tasks. To tackle these challenges, a continuous evaluation model is formulated and implemented, ensuring that each activity yielded tangible outputs, such as surveys, reports, and presentations, and that each output contributed towards their final grade. Table 1 illustrates the evaluation scheme and the expectations from each student.

Table 1

Assessment scheme to ensure completion of the assigned tasks. "I" indicates an individual activity and "G" indicates a group activity

Assessment scheme	**Expectation**
Professionalism (self-evaluation)	Active participation in the class (I)
	Completion of the review of the learning outcomes (G)
	Completion of the peer evaluation (I)
	Completion of the key take-away survey after each class (I)
Formative assessment	Presentation in the class (G)
	Submission of the reports (G)
Summative assessment	Term project report (G)
	Term project presentation (G)
	One midterm and one final authentic assessment (I)

The expectation is for students not only to complete the assigned tasks but also to attend classes regularly, actively participate in in-class activities, and assess their peers' work. As illustrated in Table 1, students are anticipated to engage in various activities throughout the semester, and are evaluated across three categories. These activities are denoted as either individual tasks ("I") or group tasks ("G"), as specified in Table 1. The professionalism grade, self-assessed by students at the course's conclusion, is based on participation, completion of peer evaluations, and the key take-away surveys conducted after each class. The purpose of the key take-away survey is for students to summarize the day's learning into a few key points, to be submitted via the learning management system by the end of the class. Formative assessments, comprising presentations and reports, are evaluated by both students and the instructor. Meanwhile, summative assessments were solely evaluated by the

instructor. One of the key components of the strategy used in this class is to engage students in evaluating their peers. The peer evaluation is completed through the learning management system. As the evaluation is used to give credit to the groups being evaluated and also to the evaluators, there is significant motivation to participate in the discussion in the class. The peer evaluation questions are shared with the students prior to finalizing their work.

Discussion and conclusion

The paper outlines a stepwise approach that was used to implement a combination of flipped classrooms and peer-to-peer learning in a management course taught in the fourth year of an undergraduate CPM program. A text analytics of all the courses taught in the program showed that the content of the course had some degree of similarity with a first-year course. From the analysis it was inferred that students can independently complete reading assignments focused on low-level cognitive tasks related to the learning outcomes of the course outside the classroom. The main elements of the combined approach involved students collaborating in a group of three to four to research the content of the assigned learning outcomes from various references, prepare reports and presentations, share and explain the concept they have learned with other peers in the class, and review content prepared by others. The instructor's role encompassed providing feedback on the contents developed by the students, delving deeper into the material to cover the learning outcomes and engaging students in higher-level cognitive tasks that included applying the concepts in solving real-life-scenarios.

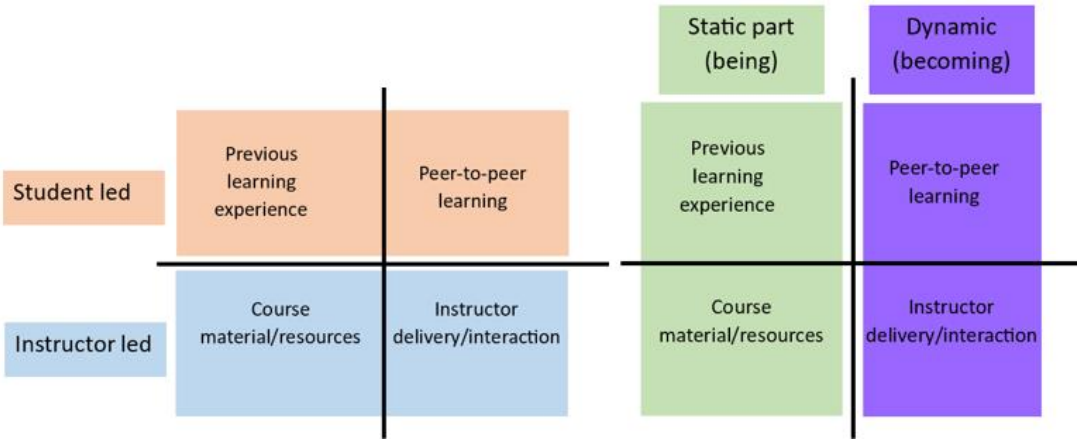

Figure 4. Learning as becoming for students in a flipped classroom with peer-to-peer learning.

This approach of the flipped classroom with peer-to-peer learning can be summarized using a model as shown in Figure 4. As shown in the figure, students take on leadership roles in creating new knowledge from their own previous experiences and from interaction with their peers. Instructors can support the students by providing learning materials and encouraging students to participate in higher cognitive tasks. The same model (Figure 4) also depicts the concept of static part and dynamic part in the learning process. As students are 'becoming' through accumulation of new knowledge and experiences, peer-to-peer learning and instructor-led interactions facilitate higher-level cognitive tasks. The feedback from the students has been very positive with a consistent improvement in their opinion about opportunities for discussion and participation in the class. Although the present study was implemented in a single course, the positive feedback from students over the years suggests that

the strategy of flipping classrooms and involving students in peer-to-peer learning and teaching is effective in teaching all level of management courses.

This study demonstrates that the model of flipped learning which combines the flipped classrooms and peer-to-peer learning and teaching (Figure 1) can be successfully applied in teaching qualitative management courses. The introduction of a scheme to evaluate every student activity plays an important role in motivating students to prepare outside the classroom and sustain continuous engagement within it. Furthermore, students' previous background in the course, inferred from text analytics results in this study, also plays a significant role in creating enthusiasm among students in engaging with course materials both inside and outside the classroom. In order to apply a similar strategy in other courses, instructors might need to assess students' previous knowledge using some other suitable methods such as pre-class assessments.

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