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Importance of Active Learning in an Undergraduate Course in Construction Scheduling

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Abstract

Students in construction majors require a variety of skills and knowledge to thrive and lead change in the industry. The learning process should incorporate strategies that ensure students acquire knowledge in the right environment, using up-to-date tools and technology that will support their education. This paper presents active learning techniques adopted in teaching an undergraduate course in construction planning, scheduling, and control. To ensure that the student learning objectives were achieved, student competence and confidence with the course material was measured through feedback surveys. Student evaluation of the coverage of the course material and their confidence in demonstrating skills gained through the course were compared for two offerings of the class by the same instructor. This study showed an improvement in student ratings of the coverage and confidence in the second offering. In assessing different approaches used in the course, students preferred active learning tasks to traditional lectures.

Introduction

Active learning is beneficial to the educational process, and it has the potential to engage students in the learning process deeply. Studies have demonstrated its success in improving critical thinking skills, collaboration, and retention of material. In active learning, students should not only be involved in activities, but they should be thinking about what they are doing [1]. Student-centered pedagogical strategies can promote student learning and retention of the material [2]. Incorporating a variety of pedagogical approaches in the classroom allows for different student learning styles to be accommodated while improving student engagement.

In engineering, common instructional techniques used include active learning, problem-based learning, cooperative learning, and collaborative learning [3]. The skills gained by incorporating these approaches are critical for students looking to pursue a career in the construction industry. Felder et al. reinforced the notion that active learning is more effective than lecturing as students can gain a deeper understanding of the material [4]. They also stressed the importance of practice and reflection in the learning process. Freeman et al. compared studies focused on undergraduate students in science, technology, engineering, and mathematics (STEM) that used active learning techniques and those that used traditional approaches [5]. Average examination scores increased by 6% in the active learning sections, thus highlighting the importance of active learning in STEM education.

Bhattacharjee and Ghosh discussed the usefulness of role-playing in construction education and emphasized how students employed critical thinking skills as they played the role of different stakeholders [6] [7]. In project-based learning, students work on real projects. Most construction programs require students to complete capstone projects as the culminating experience to earn their degrees. Students can learn higher-level cognitive skills through project-based and problem-based learning [8].

In recent years, there has been increasing use of technology to foster and support learning. Messner et al. discussed the use of immersive virtual reality in construction education, and they found that students have a better understanding of construction projects in an immersive environment using visualization tools [9]. In a flipped classroom, students work through the lecture materials at home, and the professor addresses questions during the lecture time. This approach engages students with course material outside the classroom utilizing tools made available through improvements in instructional technologies. Benefits of the flipped classroom include improvements in student-teacher interaction, opportunities for students of all abilities to excel, and improved interaction among students [10]. A study demonstrated that students in flipped classrooms sometimes learned more than those in traditional classroom settings [11]. A variety of instructional strategies can be adapted to meet student learning outcomes. Learning outcomes assessments serve as a tool for continuous improvement to drive student success [12]. Evaluation of these learning outcomes can take different forms; for instance, the use of rubrics and student evaluations.

This study emphasizes the importance of active learning and introduces the active learning techniques employed in an undergraduate course in construction planning, scheduling, and control. This paper also presents student perception of instructional strategies used in the course, coverage of the course content, and their confidence in the demonstrating understanding of the course learning outcomes.

Methodology

Seventeen students enrolled in fall 2018 and twenty-one enrolled in fall 2019; the same instructor taught both classes. The instructor's department routinely collects data on student assessment of coverage and confidence. Comparison of the mean student ratings of coverage and confidence between 2018 and 2019 was determined for each learning outcome. Coverage indicates how well the course addressed the intended learning outcomes, while confidence reflects if the students feel well prepared to implement their learning in the real world. This paper also presents student feedback on a selection of strategies used in the course for fall 2019.

Given that this is the only course the students will take in construction scheduling, most students will learn the concepts for the first time. The learning objectives are focused on helping students understand the basics and gain deeper understanding and experience by using software to develop and analyze construction schedules for real projects. In addition to this, student feedback on the activities they found the most interesting, most engaging, and their recommendations for the course was collected.

Course Description

This paper assesses approaches used in teaching construction planning, scheduling, and control to students in a civil engineering technology program. It is a three-credit undergraduate course that has been offered at the institution for five years but was updated in 2018. The course is taught once a week in a 2 hour 50-minute session. With an enrollment of twenty-one students in fall 2019, it is an elective taken by fourth and fifth-year students. It is the first scheduling course available to the students, and the majority of them started the course with little or no knowledge of the subject matter, and the most of them had no experience in creating a schedule. However, they had all completed cooperative education experiences in the construction industry.

The intended learning outcomes for the course are as follows:
1. Demonstrate the ability to recognize and understand the key parameters involved in construction project planning.
2. Demonstrate the ability to generate construction project schedules using both the arrow-diagramming technique and the Critical Path Method (CPM) technique.
3. Demonstrate the ability to monitor and update construction project schedules.
4. Demonstrate competency with the principles of resource allocation and management.
5. Understand and use tools to monitor the progress of construction projects in terms of both schedule and budget.

Active Learning Techniques Used in the Course

A previous offering of the course involved techniques such as informal groups, case studies, guest lectures, and peer review. Laboratory sessions were an integral part of the course, and they involved working through practice problems and creating schedules in Microsoft Project. The students followed step-by-step in completing the exercises and they were given take-home assignments. In-class exercises such as creating network diagrams and line of balance schedules were completed. The students work in groups on a real project to develop a construction schedule. Students completed peer assessments to evaluate their participation and assess team dynamics while working on the group project.

Active learning techniques were introduced into aspects of the course in 2019 include think-pair-share, where the students worked in small groups during lectures to answer questions and work on quick problems. The course included experiential and hands-on learning activities, including site visits. Students completed a minute paper after the site visit to summarize construction scheduling lessons they learned on the site visit. The answers on the minute papers were compiled and shared with the class. It was a great reminder of the things that were learned on the site visit. A drone demonstration session was also part of the course, the students particularly enjoyed flying the drones, and they learned about the application of drones for inspections and tracking progress in construction projects.

Self-paced learning was also used (through a flipped classroom) where the students worked towards certification for construction project management software. A flipped classroom was used for one of the class topics. Students were assigned to watch a tutorial for the material that was to be taught in that class. They completed the exercises assigned to them and followed instructions provided in the video. The instructor then reviewed the material with the students in the next lesson. Other approaches used include interactive lectures, case studies, and hands-on technology. The students worked on team projects to delve into the core concepts and consider the elements of planning and scheduling. Students were introduced to the importance of an entrepreneurial mindset for engineers and creating value to end-users, which helped them as they worked on their projects. The final project deliverables included a construction schedule, a short narrative, a summary report, and a class presentation. Peer evaluations of their team members helped the students remain accountable to one another as they worked on the project.

Results and Discussion

As part of the closing survey and course evaluations, students responded to the question about which component of the course helped them to learn the most (Figure 1). Laboratory sessions had the highest responses, followed by in-class exercises. Lectures and guest lectures received the lowest ranking. Ten (10) students selected more than one approach as the one that helped them learn the most in the class.

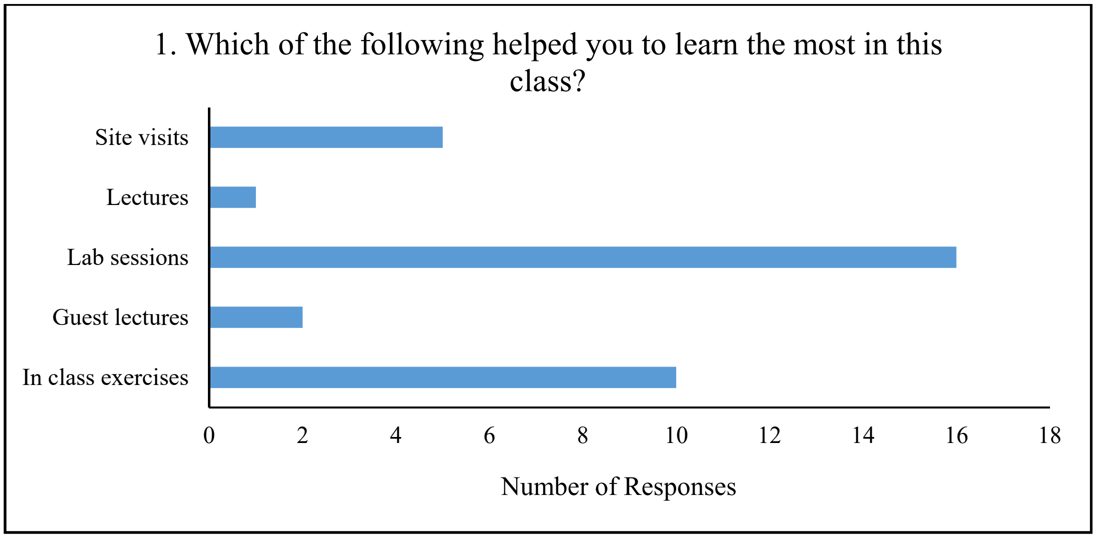

Figure 1: Approaches that helped students learn the most in the class (Fall 2019)

Three (3) invalid responses were taken out of the analysis for questions 2, 3, and 4 since the students did not rank them correctly. Five is the highest rank, while one is the lowest. Laboratory sessions were the highest-ranked as helping the students meet the learning objectives, followed by in-class exercises (Figure 2).

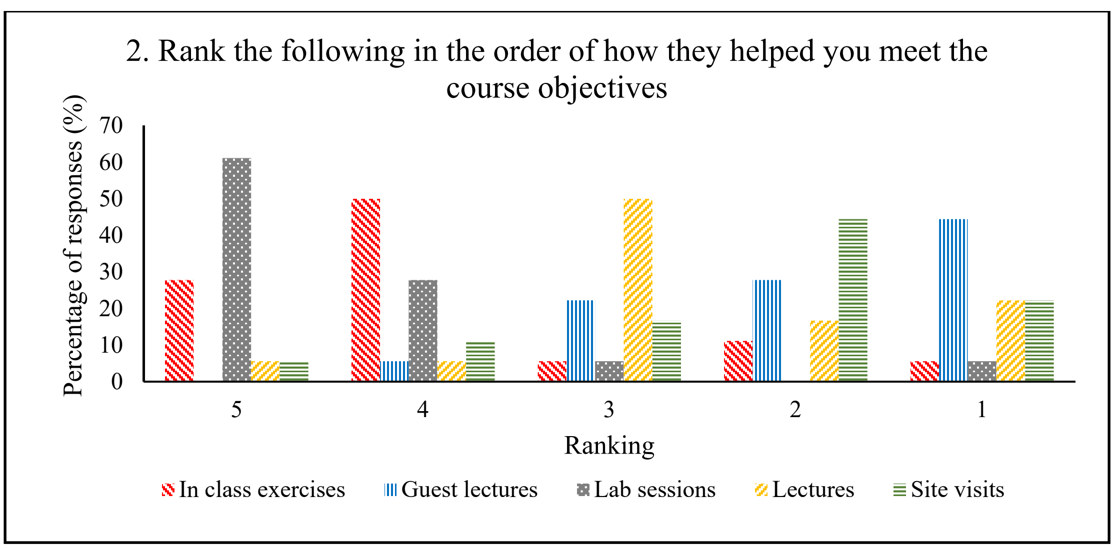

Figure 2: Ranking of activities that helped students meet the course objectives (Fall 2019)

Students found the site visits and laboratory sessions the most interesting (Figure 3). Although they did not find the in-class exercises interesting, they understood the importance of the exercises in helping them meet course objectives (Figure 2) and learn about scheduling (Figure 1). Students found lectures to be the least interesting.

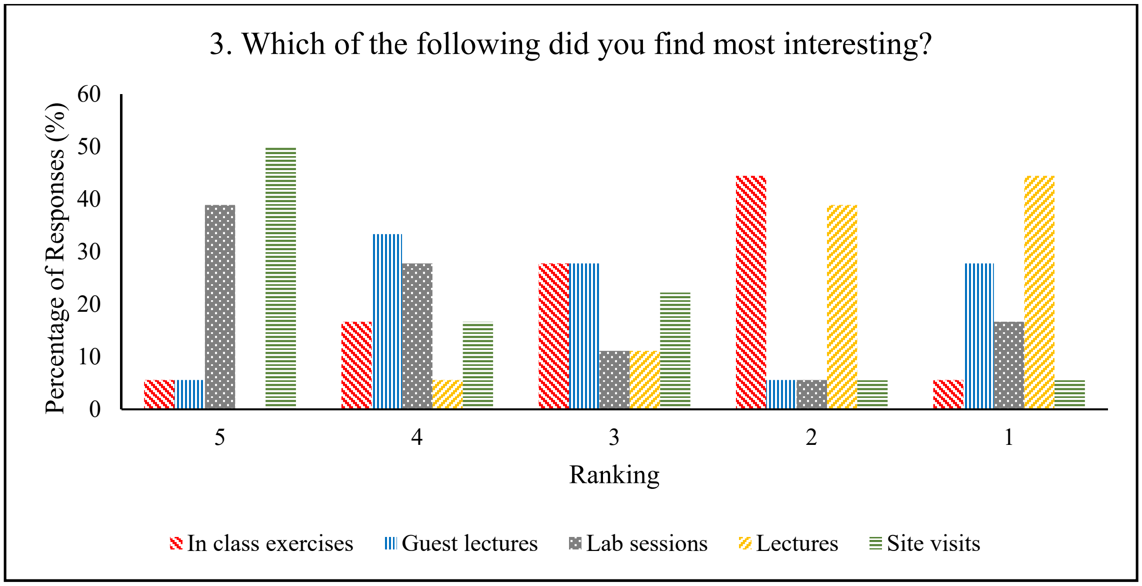

Figure 3: Approaches students found most interesting (Fall 2019)

Laboratory sessions were the most highly ranked, followed by in-class exercises and site visits (Figure 4). In-class exercises are embedded between the lectures and laboratory sessions to reinforce understanding of the material. The students felt most engaged working with software in the laboratory. The engagement levels were the lowest with the lectures and guest lectures.

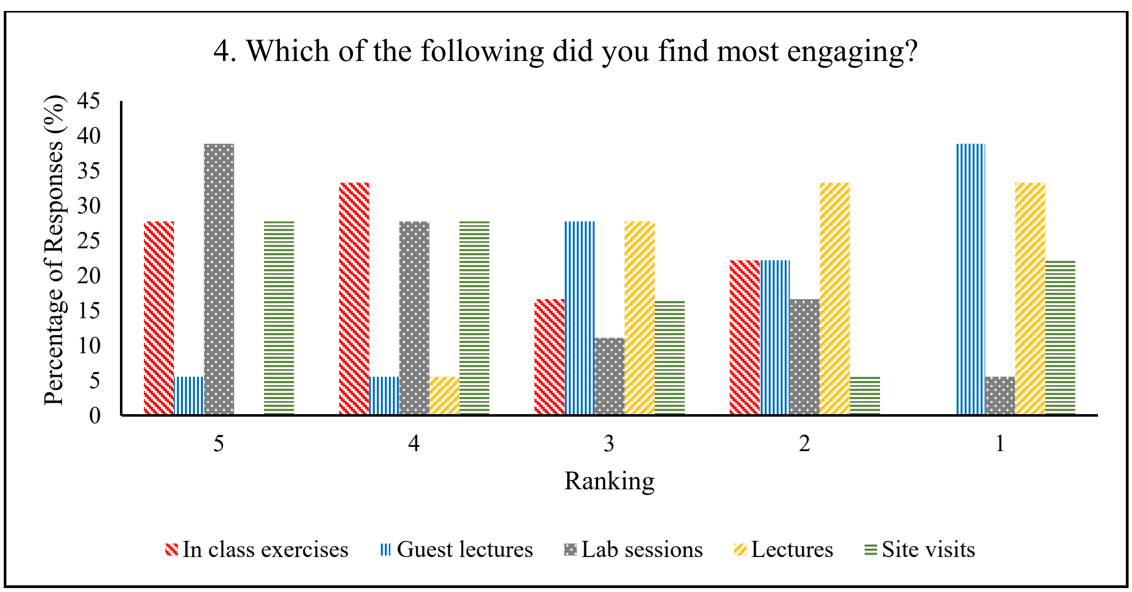

Figure 4: Approaches that students found most engaging (Fall 2019)

Students highly recommended more laboratory sessions and time spent learning and working with the software. They also recommended more in-class exercises and site visits while they recommended almost the same amount of guest lectures and lectures (Figure 5).

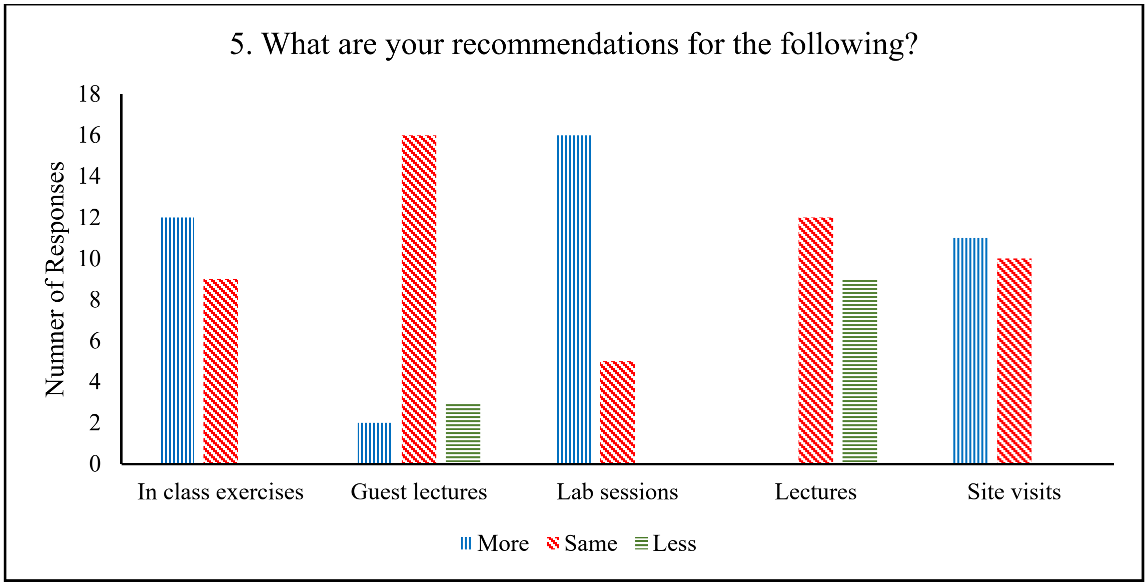

Figure 5: Students recommendations for course activities (Fall 2019)

Students also completed a survey, which is routinely distributed every semester to provide feedback on the coverage of the course intended learning outcomes and their confidence levels with each of the learning outcomes (Figures 6 and 7). The responses are on a five-point Likert scale. One is the lowest on the scale representing the least coverage, and five is the highest on the scale representing high coverage. Similar to this, one on the confidence scale indicates that they do not feel confident in demonstrating their knowledge of the material, and five means that they feel very confident. A significant difference between coverage and confidence might indicate some discrepancies. For instance, if coverage is significantly higher than confidence, then the material was well covered, but the students did not feel confident enough to demonstrate understanding of the material. This gap can be due to a lack of examples and hands-on activities to allow them to demonstrate their understanding of the material. If confidence is much higher than coverage, it could mean that the students came into the course with lots of prior experience and knowledge and they did not learn much from the course, or maybe the principles were easy to follow, and the exercises were too easy even though the course learning objectives were not met.

In the fall of 2018, there were seventeen (17) students enrolled in the course. Twenty-one (21) students enrolled in the fall of 2019. Sixteen (16) students provided feedback in 2018, while all the students provided feedback in 2019. Figures 6 and 7 show the intended learning outcomes 1-5 (each one corresponding to individual course learning outcomes presented in the course description) and the mean ratings. The mean ratings of each outcome are on a five-point scale. The coverage and confidence ratings were higher for all the intended learning outcomes in 2019 than in 2018.

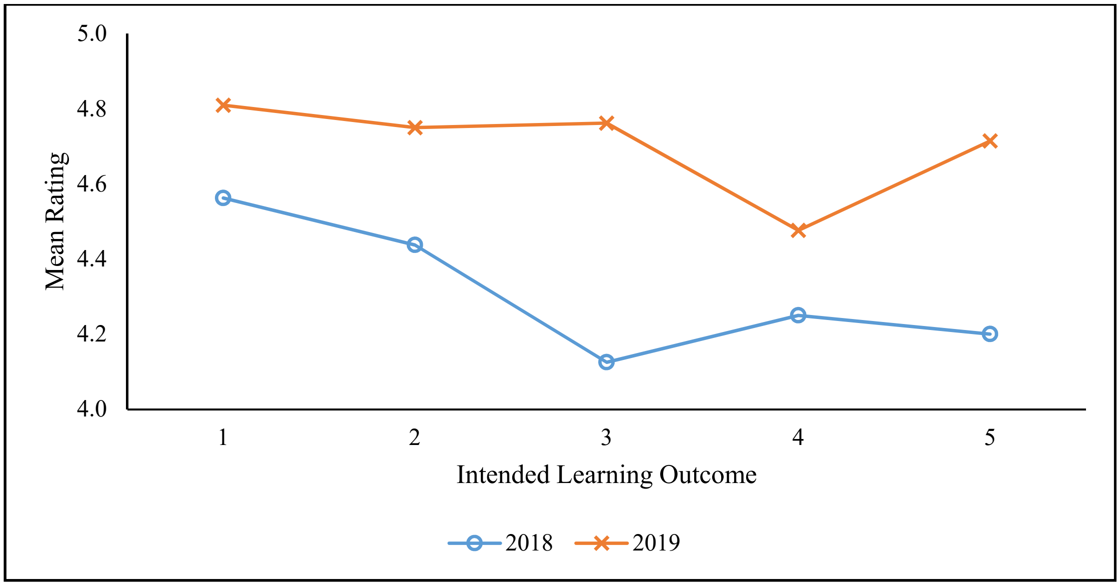

Figure 6: Coverage of course intended learning outcomes (Fall 2018 and Fall 2019)

For the learning outcome related to laboratory sessions (3 and 5), the students were slightly more confident in their skills in 2019 than in 2018. There was remarkably higher confidence in their understanding of the tools (Microsoft project and Navisworks) related to outcome 5. There is no substantial difference between coverage and confidence for the intended learning outcomes in 2018 and 2019.

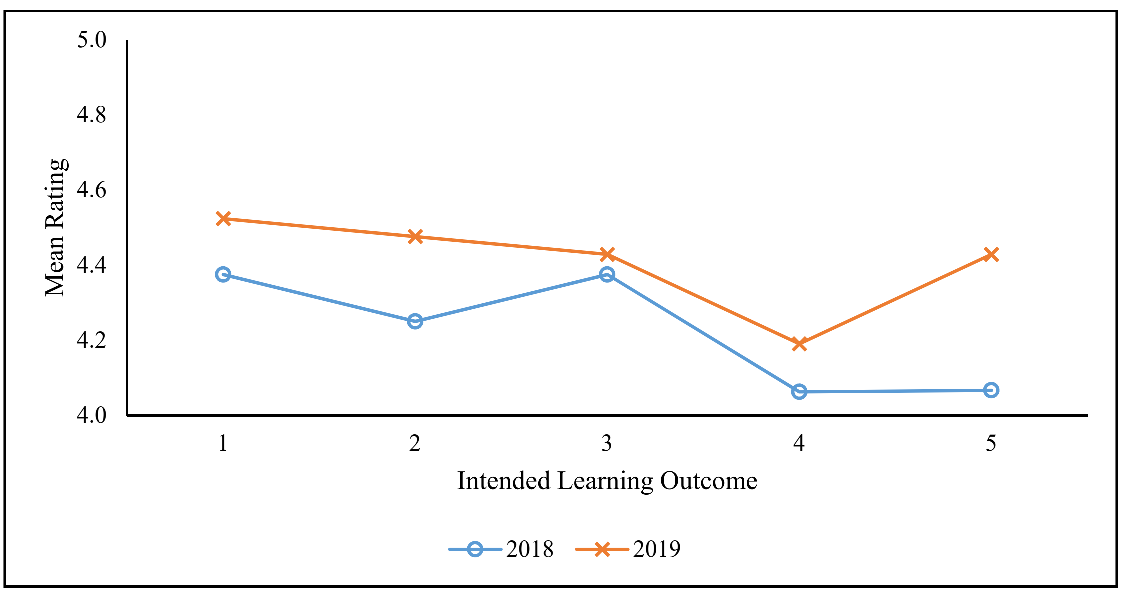

Figure 7: Confidence in carrying out tasks related to the intended learning outcomes (Fall 2018 and Fall 2019)

Overall, the students seemed to prefer laboratory sessions and in-class exercises to traditional lectures. There was an improvement in student rating of the course in 2019 than in 2018. The instructor introduced several active learning in the 2019 offering. The incorporation of active learning approaches might have improved the course, but other factors may also be responsible since the course comprised a different set of students. In addition to this, not all activities introduced to the class (i.e., the drones demonstration session) in 2019 were evaluated.

Conclusion

To sum up, this paper presented results from student assessment of a construction planning, scheduling, and control course and demonstrates the importance of active learning in construction courses. The coverage and confidence evaluations of the course learning outcomes were compared for the fall of 2018 and 2019. There was an improvement in both coverage and confidence in 2019. The students provided feedback on their perception of the course, the instructional strategies, and course activities.

Students preferred active learning approaches to traditional lectures. While they ranked traditional lectures low, these should not be eliminated. Students have different learning styles; for auditory learners, traditional lectures might be more appealing. Other approaches to make the lectures more interesting will be adopted, including the inclusion of more case studies and other active learning styles. A flipped classroom will also work well where students spend time reading the material and completing assignments outside the class, and class time is used for activities that reinforce their learning. Also, this might create more time for hands-on activities, laboratory sessions, and class exercises.

Given the nature of the construction industry, students should be able to relate their studies to real-world scenarios. The course material and instructional strategies must meet students' needs to promote student-centered learning. Active learning is critical to construction courses. Future work will explore student assessments of specific active learning strategies for different construction scheduling and planning tasks.

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