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Assessing the Effectiveness of Active-learning Approaches in Advancing Student Understanding of Construction Scheduling in a Virtual Environment

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Abstract

As demand for online learning increases, it is becoming even more critical and challenging to ensure that instructors are equipped with the requisite skills and knowledge to support student learning and accomplish associated outcomes. Many studies urge online classes to be more engaging and collaborative to provide a compatible alternative to in-person settings. Studies have explored, and many confirmed the importance of active learning in different fields. Several instructors have implemented active learning in their in-person classrooms, while only a few looked at such techniques in virtual environments. In an effort to address the gap in the literature, the authors developed an experiment that involved fifteen students who participated in a workshop covering fundamental concepts in construction scheduling. Participants were from two different institutions. They were split into two groups. One group was taught online through a traditional lecture with no prominent active learning component. They completed the practice exercise individually, while the second group was allowed to work on the practice exercise in breakout rooms on Zoom. All students completed pre and post-workshop surveys to assess students' learning of the workshop outcomes and explore the effectiveness of utilizing active learning components in online course deliveries, particularly for construction management undergraduate programs. The results of this study indicate that virtual workshops are effective in increasing students learning of construction scheduling topics. At the same time, more research is needed to confirm the effectiveness of specific active learning techniques within virtual settings.

Keywords: Active learning, virtual education, construction scheduling and planning, construction management, undergraduate education

Introduction

Students benefit from improved problem solving and critical thinking skills when active learning is employed. Active learning approaches also promote student engagement and facilitate collaboration. These approaches have been implemented in various Science, Technology, Engineering, and Mathematics (STEM) fields, enhancing students' thinking and retention of material [1, 2]. A study at Auburn University showed sixty-eight percent of the students believe an active learning environment enhanced their learning. The same study revealed that eighty-two percent of the students feel their engagement is enhanced by the space, the teaching tactics incorporated, and shared engagement between students and professors [3].

Construction majors require a variety of skills and knowledge to work effectively in the industry. A few studies have discussed active learning in civil engineering, construction, and the built environment [4, 5]. In a study conducted at Central Washington University, active learning methods were used to imitate construction industry practices. They used traditional lectures, pre and post-lab quizzes, and plan reading. The students scored higher on the lab exercise questions on the two-week follow-up quiz. They mentioned that the active learning exercise helped them remember material better for the quiz, showing that active learning is more effective than traditional lectures [6]. Another study also showed that students reported increased confidence in carrying out tasks related to the intended course learning outcomes when more active learning components were introduced to a construction course [7].

Active learning is techniques can positively improve construction students' education. In teaching topics like construction planning and scheduling, active learning techniques have been adopted to ensure that students' learning objectives are met. Studies have proved these active learning techniques to be more impactful for educational learning than traditional lectures only. When active learning occurs, the students change from being passive to being self-directed and taking responsibility for their learning. Due to this, the students and teachers work together to solve problems that will facilitate modeling, foster creativity, and enhance active and collaborative learning. Students prefer active learning strategies to conventional passive teaching methodologies [8].

With the increased adoption of virtual and online learning, some students reported that they were disengaged and lost interest in the lectures. A national survey involving 1008 students was completed during the shift from face-to-face to remote instruction due to the COVID-19 pandemic in early 2020. The survey results showed that students reported lower satisfaction levels in remote learning than in face-to-face instruction [9]. Identifying active learning approaches that could be incorporated into online classroom lectures was essential to enhance students' interest in the topics taught while ensuring continuous engagement.

As the world resorts to more online classes, active learning is no longer just incorporated in face-to-face classrooms but online classrooms as well. Face-to-face classrooms are turning into computer screens as now classes are being taught through the Internet using online web-conferencing platforms like Zoom, Teams, and Skype. One example that promotes active learning in virtual settings is the online breakout group option in Zoom, allowing students to interact and work in small groups during a virtual lecture.

In a study conducted by D'Youville School of Pharmacy, sixty PharmD students, 70% female and 30% male, were divided into Zoom breakout rooms consisting of five to six students each to complete an assignment based on the course material that was just taught. Students were encouraged to actively engage with one another through Zoom features like the chatbox and outside resources like Dropbox and Google Drive during these breakout sessions. Zoom breakout rooms allowed the instructor to move from one group to another efficiently and effectively to observe student and group progress and facilitate discussions. Overall the student's comments were positive, suggesting that online classes are moving in the right direction to promote student engagement [10]. Assessment of learning before and after instruction, through pre and post-tests, can determine the change in individuals' learning and understanding [11, 12].

This study explores the effectiveness of active learning techniques during online lectures by evaluating their impacts on student learning of basic concepts in construction scheduling and the critical path method (CPM).

Methodology

Participants were selected from two institutions – Rochester Institute of Technology and Roger Williams University. The target group was first, second, and third-year civil engineering technology and construction management students, including students who had not taken a construction scheduling course before. The target group was sent email invitations. Incentives were offered to the participants as a way to facilitate recruitment. Both institutions' human subjects review boards approved the study, and all participants acknowledged the informed consent forms.

Twenty-six students registered for the workshop, but only fifteen students showed up on the day of the workshop and participated. An online pre-workshop survey was distributed to the participants at the start of the workshop before the lecture was delivered. The pre-workshop survey was conducted to screen and ensure that the participants were qualified to participate in the workshop. The researchers also tested their knowledge through the pre-workshop survey to establish a baseline of their knowledge. The pre-workshop survey included eleven background and demographic questions and ten questions related to construction scheduling. The post-workshop survey included only the construction scheduling questions.

The workshop was conducted through Zoom and delivered by two graduate students, one from Rochester Institute of Technology and one from Roger Williams University. The workshop's focus was to introduce students to construction scheduling and test their understanding of the CPM. The graduate students who delivered the workshop were trained virtually over 3.5 months by two full-time faculty from two different institutions offering courses in construction scheduling. The graduate students were intentionally kept as active contributors and co-creators in the development of all components of the workshop.

The program for the workshop and the duration of each activity are provided in Table 1**.** The learning outcomes of the workshop were to:

- Explain how the construction industry uses network diagrams to plan and control projects
- Perform forward pass and backward pass calculations on a precedence diagram
- Determine project duration from a precedence diagram
- Identify total floats of activities on a precedence diagram
- Identify critical activities and the critical path(s) on a given schedule

The workshop was split into two parts. The first part included a lecture, and the second part was some time for the students to work on an exercise. During the lecture, participants were told to save all their questions until after the workshop. For the exercise, the participants were either placed into breakout groups using the Zoom breakout room feature or left to work on the exercise independently. The exercise was to complete a forward-pass and backward-pass on a simple network diagram and identify the early start, early finish, late start, late finish, and total float for each activity. The participants were also asked to determine the critical activities and critical path.

The participants were brought back together in the same zoom session after about 10 minutes, and three simple poll questions were asked. They were asked if they completed the exercise, if they got the correct total duration, and if they identified the critical path. The instructor then reviewed the solution to the exercise. The participants were given a post-test, which featured the same questions as the pre-workshop survey to assess the change in the participants' understanding of construction scheduling. The pre and post-workshop surveys were timed, but participants were allowed additional time to finish. The entire workshop took just over one hour.

Table 1. Planned duration vs. actual duration of the workshop

Planned Duration (minutes)	Actual Duration (minutes)	Activity
5:00	1:33	Introduction
8:00	11:09	Pre-workshop survey
2:00	0:43	Description of learning outcomes
18:00	19:20	Lecture and quick exercise by the instructor
10:00	11:01	Individual work/ breakout groups
0:00	3:56	Solutions to the exercise
12:00	11:44	Post-workshop survey
3:00	0:21	Question and answer session
2:00	2:12	Wrap up and review key points

Results

A total of 15 students attended the workshop. One of the students left the workshop after completing the pre-workshop questionnaire. In the end, 14 students completed the pre-workshop questionnaire, the workshop, and the post-workshop questionnaire. Approximately 43% of the participants are Civil Engineering Technology students at Rochester Institute of Technology, while 57% were Civil Engineering, Construction Management, and Architecture students at Roger Williams University. Figure 1 illustrates different majors the participants are studying at their respective institutions. Although all the participants are studying in construction-related areas, none of them have taken any scheduling courses. They described their level of exposure to construction scheduling as either minimal or none.

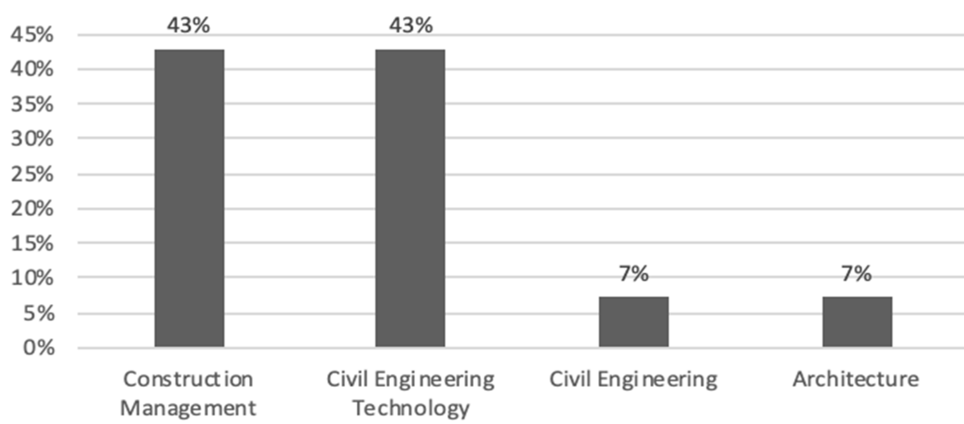

Figure 1. Majors of students who attended the workshop

Approximately 20% of all workshop participants were female students. 72% identified themselves as Caucasian, while 28% were African-American, Latino or Hispanic, Mixed Ethnicity and Undisclosed, each group holding an equal 7% of the total number of attendees. 72% of the participants had a cumulative GPA of 3.00 and above (Table 2).

Table 2. Cumulative GPA distribution of workshop attendees

Cumulative GPA	Percentage
Less than 2.49	0%
2.5-2.99	14%
3-3.49	36%
3.5-4	36%
Undisclosed	14%

Due to the small sample size, none of the variables collected from the post-workshop questionnaire were normally distributed except the following variables:

- Time the participants took to answer the scheduling questions in the post-workshop questionnaire.
- Total scores of participants from the scheduling questions in pre and post-workshop questionnaires.
- Improvement of students' scheduling test scores (the difference between post and pre-workshop scores).

Normality analyses were conducted using Shapiro Wilk and Skewness/Kurtosis tests. The authors conducted non-parametric statistical analyses using chi-square or Wilcoxon-Signed Rank tests for variables that are not normally distributed. T-tests were used to analyze the workshop's and the breakout room's impacts using pre and post-workshop scheduling test total scores. Due to the small sample size, the authors determined 90% as the confidence interval for the statistical analyses reported in this study.

Table 3 illustrates the percentage of students' who answered each question correctly in pre and post-workshop tests. Based on the Wilcoxon-Signed Ranks tests conducted to compare mean ranks of students' pre and post-workshop answers to each scheduling question, participants performed significantly better in every scheduling question administered after the workshop (Table 3). The authors found no significant difference between the students' cumulative GPA and their performance in pre or post-workshop tests.

Results of a paired samples t-test confirmed that the total post-workshop test scores were significantly higher $(M = 7.71, SD = 1.858)$ than the pre-workshop total test scores $(M=1.93, SD = 1.269)$, $t(13) = 8.035, p = 0.000$.

Table 3. Students' pre and post-workshop scores

Question	Pre-workshop Correct (%)	Post-workshop Correct (%)	Difference [Post-Pre workshop] (%)	Sig 2-tailed
1	42.86	92.86	50.00	.008
2	57.14	85.71	28.57	.046
3	7.14	85.71	78.57	.001
4	35.71	85.71	50.00	.002
5	0	71.43	71.43	.02
6	0	50	50.00	.008
7	28.57	92.86	64.29	.003
8	0	64.29	64.29	.003
9	7.14	78.57	71.43	.002
10	14.29	64.29	50.00	.02

Independent samples t-tests were conducted to identify the differences between means of each normally distributed non-binary variable between subjects who attended a breakout room during the workshop and those who did not. The results of the t-tests show that although the mean test scores of those who participated in a breakout room were higher than those who did not, there were no significant differences at or higher than the 90% confidence level (Table 4).

Table 4. Differences in overall scores of those that attended a breakout room and those that did not

	Attended a Zoom breakout room?	Mean	Std. Dev.	Mean Diff.	Sig. (2-tailed)
Post-Workshop Overall Test Scores	No	7.29	2.21	-0.86	0.410
	Yes	8.14	1.46		
Improvement from Pre to Post-Workshop	No	5.00	3.06	-1.57	0.293
	Yes	6.57	2.23		
Duration subjects took to answer the Post-Workshop test	No	303.71	190.07	90.43	0.266
	Yes	213.29	76.38		

Although it is encouraging to have an increase in the scores of those who participated in the active learning strategy, lack of a significant difference between the two groups may need to be further investigated. The authors are planning to continue this research with more subjects under similar delivery circumstances, to further confirm or reject any potential differences in the performance of students attending a breakout room or not.

The percentage of correct answers to the post-workshop scheduling test grouped based on those who attended a breakout room during the workshop and those who worked entirely on their own during the workshop are given in Table 5. Table 5 also shows the results of chi-square tests of independence that were performed to examine the relationship between students' performance in each scheduling question and their involvement in active learning (attending a breakout room during the workshop).

Table 5: Differences in individual question scores of those that attended a breakout room and those that did not

Question Number	Attended breakout room?	Percent Correct	Percent Difference	Pearson Chi-Square	df	Asym. Sig. (2-Sided)
Q1	No	85.7%	14%	1.077	1	0.299
	Yes	100.0%				
Q2	No	71.4%	29%	2.333	1	0.127
	Yes	100.0%				
Q3	No	85.7%	0%	0.000	1	1.000
	Yes	85.7%				
Q4	No	100.0%	-29%	2.333	1	0.127
	Yes	71.4%				
Q5	No	57.1%	29%	1.400	1	0.237
	Yes	85.7%				
Q6	No	42.9%	14%	0.286	1	0.593
	Yes	57.1%				
Q7	No	85.7%	14%	1.077	1	0.299
	Yes	100.0%				
Q8	No	71.4%	-14%	0.311	1	0.577
	Yes	57.1%				
Q9	**No**	**57.1%**	**43%**	**3.818**	**1**	**0.051***
	Yes	**100.0%**				
Q10	No	71.4%	-14%	0.311	1	0.577
	Yes	57.1%				

Although students who participated in the breakout group were more successful in answering most of the scheduling questions, it was challenging to identify significant differences between the two groups due to the low number of subjects. However, the relationship between students' performance in one of the advanced scheduling questions (question 9) and their breakout room attendance was significant at 90% confidence level, X^2 (1, N = 14) = 3.818, p = .051. Question 9 could be considered a relatively difficult question since it required students to fully complete a forward and backward pass and accurately calculate the "Late Finish" date of one of the activities within a precedence diagram.

Conclusion

This study illustrates that a virtual construction scheduling workshop can significantly increase students' understanding of basic scheduling principles and CPM calculations regardless of their GPA. Furthermore, results indicate that active learning techniques may improve students' performance particularly when teaching more complex concepts. However, more studies with larger sample sizes are needed to confirm statistical improvements in the performance of those who participate in active learning techniques during virtual education. The authors did not analyze the impact of demographics except the GPA due to the small sample size in this experiment. Future studies will focus on identifying if demographics such as gender and ethnicity play a role in students' performance in virtual education and active learning techniques in such settings.

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