Utilizing a Flipped Learning Approach to Construction Cost Estimating: Fostering Increased Student Engagement in Guided Active Learning Experiences

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Introduction:

Learning the art of construction estimating is invaluable to a student's overall understanding of the construction process and in promoting workforce readiness. With limited contact hours each week, the traditional face-to-face lecture and tutorial-based format can impede engagement and learning, not allowing time for quality student-student and student-faculty interaction. The flipped classroom incorporates a blended format allowing students to acquire the necessary knowledge outside of the classroom, prior to engaging in hands-on active learning in the classroom.

Most cost-estimating courses are taught later in a program's curriculum and require prerequisite coursework to ensure students have the appropriate knowledge and skills necessary for successful comprehension and application. A student's level of knowledge entering a cost estimating class can be impacted by their requisite coursework success, quality of transferred coursework from another institution, and industry work experience. The flipped learning model allows students to view lectures and learning materials at their own pace, acclimating to the required knowledge prior to class and allowing class time for problem-solving and collaboration with peers and the instructor.

This study summarizes the results of implementing a flipped learning approach to a construction management cost estimating course. Mixed methods were used to collect quantitative and qualitative data. Findings analyzed student perceptions and indirect and direct assessments of student achievements. The outcomes of the flipped approach indicated most students perceived benefiting from the flipped learning environment, with a positive impact on student achievement, comprehension of course material, and stronger student-to-student, and student-to-faculty engagement. Furthermore, results reinforced the need to tailor pre-class materials for increased student participation and assimilation of concepts prior to in-class activities.

Purpose:

To better serve students, a flipped learning approach was adopted for a university cost estimating course to foster increased student-to-student and student-to-faculty engagement and improve the overall guided active learning experience and student achievement. This paper discusses the course's flipped learning format along with the technology used to support its implementation and seeks to understand the benefits and potential disadvantages of student outcomes and perceptions. Direct assessment data for two semesters, Fall 2021 and 2022, is analyzed including assigned homework, labs, quizzes, exams, a final project, and overall course grades as a culmination of student course performance. Student surveys of the course's flipped learning format provide an indirect assessment of student perceptions and were gathered for Fall 2022. Additional data will be gathered in future semesters, as will direct and indirect assessment data when students complete their senior capstone project.

Furthermore, this paper presents a review of the literature discussing related research and the pedagogy of flipped learning. It provides a basis for the rationale of implementing flipped learning in the university classroom and strategies for construction management programs.

It is the authors' intent to discuss this topic within the framework of the university construction cost estimating course, with the goal of providing knowledge for construction programs and the effectiveness of flipped learning.

Literature Foundation:

Research indicates an increased interest in using a flipped learning model at the university undergraduate level to foster student academic achievement. The flipped learning approach is defined as student-centered where students "take an active role in their learning" and instructors are "learning facilitators" [1]. This differs from traditional classroom instruction which focuses on a lecturer-centered model. A flipped classroom is an inversion or reversal of the traditional lecture followed by homework assignment model, it moves the lecture content before class and assignments or hands-on activities during class. "Events that traditionally have taken place inside the classroom now take place outside the classroom and vice versa [2]." Students are introduced to course material and concepts before class, allowing in-person class time for students to engage in active learning and problem-solving, utilizing the support of peers and the instructor. Student academic engagement, peer engagement, and faculty engagement have been identified as three key components that positively impact student learning, academic performance, and retention. The flipped classroom focuses on these same engagement practices, and research findings suggest there is "improved student learning and positive perceptions within the flipped classroom [3]."

A well-structured flipped classroom motivates students to engage and take an active role in the learning process. The course design should incorporate various tasks and learning activities that connect concepts in different formats, allowing students to experience concepts in multiple contexts [4]. Typical student activities for flipped learning outside of the classroom include asynchronous online video lectures, multimedia materials, closed-ended problems, and quizzes [5]. These outside activities should allow students to gain an understanding of course material and fill in their knowledge gaps. A focus group study by McCallum, *et al.* [3] indicated when students have 24/7 access to lectures, they can control the pace they learn, and it eases note-taking, which positively impacted their learning. Students "felt more prepared for class, making the in-class experience more productive." Many students are hesitant to ask questions during in-class lectures. With the students' ability to replay the lectures several times, it allows them to formulate questions outside of class and seek assistance from the instructor during their feedback sessions [6]. However, some students struggle with self-discipline and completing pre-class activities. It's important to create outside classwork and quizzes with associated points and grades to incentivize student involvement and engagement with the material [7], [3]. Studies indicate [3] "one of the most effective learning activities perceived by students is pre-class online quizzes preparing them for in-class activities."

With lectures, exercises, and quizzes implemented outside of class, this expands the course curriculum versus just being a rearrangement of activities [5]. By removing the lecture portion

from class, more time is allowed for interaction and engagement between the instructor and students. The instructor's focus shifts to that of providing expertise and facilitating support, while promoting interaction and student understanding of how "experts think through problems within their field [8]." Lee and Kim [9] implemented a study comparing the flipped classroom versus lecture-based for a Construction Engineering and Management course for learning the estimating concepts and principles for site work and concrete. Results indicated students perceived positive benefits of the flipped classroom due to the increased interactive in-class work and engagement with faculty. More time for student-faculty engagement also provides instructors with greater insight into students' grasp of information and learning [6].

Active learning and student-to-student interaction is another key element of flipped learning. The incorporation of face-to-face interaction and in-class activities is a critical component and requires creating and implementing effective group activities for student-centered learning and engagement [5]. Developing communication and interpersonal skills is important for preparing students for the construction industry. A case study by Mojtahedi, *et al.* [4] supported previous research that students in a flipped classroom demonstrated an increased desire to interact with their peers, explain concepts, and learn from each other, providing "more opportunities for collaboration and problem-solving" while increasing student communication skills.

Incorporating active learning strategies has shown positive results in engaging students and strengthening knowledge and higher levels of achievement. Today's millennial students have grown up with technology and process information differently than past generations. Prensky [10] discusses the millennial as "digital natives" and how they have access to information at their fingertips preferring to learn in an active and collaborative environment. Educators need to move from "rote memorization of knowledge and facts" or "surface learning" to "deep learning" which is supported through active and interactive processes [6]. A hybrid flipped classroom format was implemented for two Construction Management and Engineering courses at Georgia Southern University. Student performance was measured for the flipped format class and the same course implemented in a traditional format. Results indicated a significant difference, clearly illustrating the flipped approach improved student performance and learning [1].

Pourmand, *et al.* [11] implemented a study comparing the flipped versus traditional classroom and the impact on the technical communication skills of construction students. The flipped classroom format included pre-class, in-class, and post-class activities. Pre-class activities included ten 4 to 10-minute-long lecture videos each ending with reading assignments and brainstorming questions. In-class activities involved question-and-answer group discussions and sharing of ideas facilitated by the instructor, active learning group assignments, and short 10-minute quizzes. Data was measured by evaluating course grades for project presentation and report-writing. They used "parametric and nonparametric hypothesis testing on means to determine whether the higher presentation grade and report-writing grade (if any) is due to random chance or statistically significant." Results indicated the learning strategies incorporated in the flipped format "significantly improve the technical communication skills of construction students with different abilities, backgrounds, and levels of knowledge."

Several studies [7], [2], [1] have evaluated student perceptions of the flipped classroom for several types of courses and degrees of study at the university level. Evidence suggests that

students in general prefer the flipped classroom to the traditional lecture. McCallum, *et al.* [3] found that students "felt more prepared for class." They perceived the in-class experience to add significant value and improve their in-class experience by making learning more accessible, increasing their involvement, and the opportunity to collaborate with others. The study indicated that increased student-student engagement within a flipped classroom is positively perceived as providing students the ability to receive help and feedback from peers allowing "peer relationships to be built and peer knowledge to be shared." Mojtahedi, *et al.* [4] found that students in the flipped classroom "exhibited a desire to want to explain concepts to other students, feeling as though this is the best way to learn something thoroughly." Studies have also connected the flipped classroom with positive student perceptions and student-faculty interaction. Per McCallum, *et al.* [3] with more time to interact with the instructor during class time, students perceived faculty as "more approachable and accessible" and contacting faculty outside of class more comfortable. Students also indicated that they perceived the instructor as having a better understanding of the student's abilities and knowledge level.

Methods:

This study seeks to examine the implementation of a flipped learning approach to construction cost estimating and its impact on student achievement. Key technologies utilized to provide a flipped classroom experience include Canvas as the learning management system, Kaltura for storing and streaming videos, PowerPoint for recorded lectures, and Zoom for ad-hoc instructional videos. All pre-recorded lectures and instructional videos, practice quizzes, and additional resources were posted to Canvas and made available to students 1 week prior to covering related material in class. Short in-class quizzes were included at the start of each class session to provide an incentive to complete pre-class work. The in-class lecture for the course focused on the application of the pre-class material using guided practices including group activities, discussions, and problem-solving.

A mixed-method approach was used to collect both quantitative and qualitative results. An end-of-semester survey was developed and delivered using Qualtrics (https://www.qualtrics.com) targeting the use of a flipped classroom approach in a construction cost estimating course as an indirect form of assessment. The student survey consisted of 27 questions supporting responses to 8 different categories: availability of pre-class material, student effort and use of pre-class material, quality of course material, impact on engagement, best use of time, workload, the overall perception of a flipped learning environment, and student perception of achievement. The questions were developed utilizing a combination of existing surveys focused on similar topics and then tailored to suit a flipped classroom environment along with the creation of new questions to target student interactions with the material, other students, and the instructor. The majority of these questions utilized a 4-point Likert scale (1-strongly agree, 2-agree, 3- disagree, and 4-strongly disagree). A 4-point scale was selected to remove the neutral dumping ground and require students to select a side. Additional scales include another Likert scale (1-extremely adequate, 2-somewhat adequate, 3-somewhat inadequate, 4-extremely inadequate) and a rating scale (4-1, 4 being the best and 1 being the worst). The survey also incorporates 1 ranking question focused on the impact of individual course elements on understanding the required material and 2 open-ended questions elaborating on the pros and cons of a flipped learning environment.

The institutional review board (IRB) approved the study prior to solicitation. An email was sent out to inform each student of the survey subject matter, the format, the approximate time to complete the survey, and provided an anonymous link employing Qualtrics. The email also disclosed that participation was voluntary but if 90% participation was achieved students would earn 25 points of credit toward lab work. Once published, the surveys remained open for 2 weeks. The goal of the survey was to identify students' perception of the implemented flipped learning approach in a construction cost estimating course as a form of indirect assessment.

A total of 17 undergraduate students within the Construction Management program were solicited to participate in the survey in the Fall of 2022 at the time of their enrollment in the course. An 88% response rate was achieved for a total of 15 participants.
A second anonymous questionnaire was distributed to students enrolled in the course using the Canvas survey tool. The questionnaire included 4 questions, also developed using a 4-point Likert scale (1-strongly agree, 2-agree, 3- disagree, and 4-strongly disagree). A total of 17 undergraduate students within the Construction Management program were solicited to participate in the survey in the Fall of 2022 at the time of their enrollment in the course. A 94% response rate was achieved for a total of 16 participants.

In addition to the student survey, student scores were collected for the Fall of 2021 and the Fall of 2022 to use as a comparison for pre and post-intervention and as a direct form of assessment including homework, labs, quizzes, exams, a final project, and final course grade. All identifiers were removed and data was collected based on 22 students participating in the construction cost estimating course in the Fall 2021 and 17 students participating in the Fall 2022. Supplementary direct and indirect assessment data will also be assessed for the same cohort of students when students complete their senior capstone project at a later date.

Results

Tables 1-8 present the students responses and perception of questions associated with each of the 8 general categories pertaining to the implementation and use of a flipped classroom approach in the construction cost-estimating course.

Availability of Pre-Class Material – FALL 2022				**N=15**
Survey Questions	**Strongly Agree**	**Agree**	**Disagree**	**Strongly Disagree**
Pre-class material was available online before the classroom activity	60%	40%	0%	0%
Pre-class material was provided well in advance to allow adequate time for review outside of class	60%	40%	0%	0%

Table 1 Availability of Pre-Class Material

The availability of pre-class study material and assigned work is directly related to students' ability to interact with the material and complete assignments prior to the specific material being covered in class. Setting a minimum timeline and adhering to it sets the expectation for both the

students and the instructor. The pre-class material for the construction management course was made available 1 week prior to covering the material in class, providing an opportunity to review and complete assigned work, without allowing students to work so far ahead of schedule as to cause confusion. Table 1 shows that all students participating in the Fall of 2022 survey agree that material was available prior to the classroom activity and provided early enough to allow adequate time for review outside of class.

Quality of Course Material – FALL 2022				N=15
Survey Questions	**Strongly Agree**	**Agree**	**Disagree**	**Strongly Disagree**
Pre-class material was easily accessed and well put together	40%	53.33%	6.67%	0%
Pre-class material was relevant to the class activities	60%	40%	0%	0%
Material posted online helped me better understand the material each week	20%	80%	0%	0%
Activities during class improved my understanding of key concepts in the course	33.33%	66.67%	0%	0%
Class quizzes helped me to better understand the material	33.33%	53.33%	13.33%	0%

Table 2 Quality of Course Material

Care must be taken to develop the course material so that it enhances the course content and delivery in a manner that supports student understanding and achievement. An effort was made to recreate in-class lectures online to mirror what was previously provided during class time. Full presentations were provided with audio prior to class time to walk students through weekly material in preparation for a more engaged active learning environment in class. In an effort to support and better assess student understanding, pre-class practice quizzes designed with multiple attempts were also developed to mirror the expectations of the timed in-class quizzes replacing the open-book, open-note take-home quizzes previously utilized. Table 2 shows that all students participating in the Fall of 2022 survey agree that the material posted online helped them understand the material each week, pre-class material was relevant to the class activities, and that class activities improved their understanding of course concepts. 93.33% of these students agree that the pre-class material was easily accessed and well put together, and 88.66% agree that the in-class quizzes improved their understanding of the course material.

Student Effort and Use of Pre-Class Material – FALL 2022				N=15
Survey Questions	**Strongly Agree**	**Agree**	**Disagree**	**Strongly Disagree**
I reviewed the pre-class material before class	6.67%	73.33%	6.67%	13.33%
I reviewed the pre-class material during the semester	26.67%	53.33%	6.67%	13.33%
	Extremely Adequate	**Somewhat Adequate**	**Somewhat Inadequate**	**Extremely Inadequate**

How much effort did you put into reviewing pre-class material before coming to class	6.67%	73.33%	13.33%	6.67%

Table 3 Student Effort and Use of Pre-Class Material

In regard to the utilization of a flipped classroom approach, the pre-class material only helps if students engage in the material, preferably prior to the class but still providing a benefit as a reference tool even after the class activities are completed throughout the semester. In-class quizzes were designed to improve pre-class student interaction with the material but did not cover the breadth of the pre-class material provided to students. As a result, Table 3 shows that only 6.67% of the students participating in the survey strongly agree that they had reviewed the pre-class material prior to class while 26.67% agree that they reviewed the pre-class material at some point during the semester. Overall, 80% of the students agree that they had reviewed the pre-class material prior to class, with 20% responding that they had not reviewed the pre-class material at any point during the semester.

Impact on Engagement – FALL 2022				**N=15**
Survey Questions	**Strongly Agree**	**Agree**	**Disagree**	**Strongly Disagree**
The extra time solving problems in class helped me to engage with the material more	26.67%	73.33%	0%	0%
The extra time solving problems in class helped me to engage with the instructor more	33.33%	60%	6.67%	0%
The extra time solving problems in class helped me to engage with other students more	40%	53.33%	6.67%	0%
The active learning environment made me feel more comfortable interacting with the instructor	40%	53.33%	6.67%	0%
The active learning environment made me feel like the instructor was there to guide me through the work	40%	53.33%	6.67%	0%
The instructor was able to actively engage with me and other students using the flipped classroom approach	53.33%	26.67%	20%	0%
The flipped classroom approach gave the instructor more time to provide clarification on difficult concepts in the course	40%	53.33%	6.67%	0%

Table 4 Impact of Engagement

One key concept in utilizing a flipped learning environment is to increase the amount of time in class to engage students as opposed to teaching at them. Table 4 shows the results of the impact of implementing a flipped classroom approach on student engagement in the classroom. Overall, 100% of the students surveyed reported that the increased time spent on problem-solving increased their engagement with the material. 93.33% of the students agree that the time spent solving problems in class and the active learning environment increased student engagement with the instructor, making the students more comfortable with the instructor and allowing the instructor to provide clarification on more difficult concepts while also increasing student-to-student interactions. Increased instructor interaction within the class may not equate to individualized student-to-instructor interaction. Only 80% of the students surveyed reported that the environment allowed the instructor to actively engage with them as an individual.

Best Use of Time – FALL 2022				N=15
Survey Questions	Strongly Agree	Agree	Disagree	Strongly Disagree
The flipped classroom experience was a better use of time in class allowing me to understand the material better	33.33%	66.67%	0%	0%
The extra time solving problems in class helped me understand the material	20%	80%	0%	0%
The flipped classroom experience was a better use of time in class allowing me to get a jump start on assigned work	40%	60%	0%	0%
I would prefer the pre-class material be taught live in class in place of the extra time spent on problem-solving	0%	33.33%	46.67%	20%

Table 5 Best Use of Time

Another key concept of utilizing a flipped learning environment is the use of time. The idea is to use time outside of class for students to better prepare for in-class activities. Each student enrolls in class with varying degrees of prerequisite knowledge. The pre-class material allows students to improve their knowledge base at their own speed outside of class prior to actively engaging with the class as a whole. This also increases the amount of time available in class to focus on the application of concepts rather than review the background information supporting these concepts. Table 5 provides student responses to whether utilizing a flipped classroom approach was the best use of class time or not. 100% of the students participating in the survey agree that a flipped classroom experience provided a better use of in-class time, increasing their understanding of the course material and allowing them to get a jump start on assigned work. Though all students agree with the better use of time, 33.33% of the student responses favored a traditional in-class lecture approach to covering the pre-class material.

Workload – FALL 2022				N=15
Survey Questions	Strongly Agree	Agree	Disagree	Strongly Disagree
The pre-class material placed more work on me outside of class	20%	40%	40%	0%
The pre-class material placed a reasonable amount of work on me outside of class	6.67%	53.33%	40%	0%
The extra time reviewing pre-class material outside of class was balanced with allowing more time in class to work through assigned activities	13.33%	66.67%	20%	0%

Table 6 Workload

A flipped classroom approach should still provide some semblance of an acceptable student workload when compared to a traditionally delivered lecture experience. The purpose of developing pre-class material to be reviewed and completed by students outside of class is to allow students time to prepare for class activities at their own pace and to make class time more engaging and productive. It also moves basic material, supporting content, that students can digest on their own outside of class allowing time in class to cover more difficult concepts and

applications with the guidance of the instructor. Table 6 shows student responses to the workload placed on them due to the design of the flipped classroom for the construction cost estimating course. Results show that 60% of the students agree that the flipped classroom approach increased their overall workload outside of class. 60% of the students also agree that the workload outside of class was reasonable. 80% of the students agree that the additional pre-class material was balanced with allowing more time in class to work through assigned activities that would have previously taken place outside of class time.

Overall Perception of a Flipped Classroom – FALL 2022				N=15
Survey Questions	4	3	2	1
In a flipped classroom environment, traditional lecture material and other prep material are posted for review online outside of class prior to class. How would you rate a flipped classroom approach? (4 being the best and 1 being the worst)	20%	60%	20%	0%
	Yes	No		
Do you prefer a flipped classroom approach to a traditional classroom approach?	66.67%	33.33%		

Table 7 Overall Perception of a Flipped Classroom

Table 7 provides student responses as they relate to the overall perception of utilizing a flipped classroom approach in the construction cost estimating course when compared to other methods of course design and specifically the traditional lecture approach. 20% of the students surveyed rate the flipped classroom approach as a 4, with 4 being the best method and 1 being the worst, while 60% rate a flipped classroom approach as a 3. Additionally, 66.67% of the students prefer the flipped classroom approach to a traditional classroom approach.

Student Perception of Achievement – FALL 2022				N=15
Survey Questions	Strongly Agree	Agree	Disagree	Strongly Agree
The pre-class material and the class activity made me confident to complete the work in the course	40%	60%	0%	0%

Table 8 Student Perception of Achievement

Table 8 shows that 100% of the students participating in the survey agree that the pre-class material and the class activity made them confident in their ability to complete the work in the course. Additional direct assessment measures of course achievement is provided in Table 13.

Tables 9 and 10 present the students' responses and perception of which course element best-supported student learning given the flipped classroom approach utilized in the construction cost-estimating course. Table 9 displays the selected order of importance reported for within each rank while table 10 provides the overall mean score and the resulting order of importance.

Which of the following items helped you to better understand the course material? (Rank in order of importance with 1 being the most important) – FALL 2022					N=15
Course Elements	**Rank**				
	1	**2**	**3**	**4**	**5**
Posted Videos	28.57%	35.71%	21.43%	14.29%	0%
Class Activities	42.86%	28.57%	28.57%	0%	0%
Quizzes	0%	7.14%	14.29%	28.57%	50.00%
Feedback provided on the assignment	7.14%	14.29%	21.43%	42.86%	14.29%
Meeting with the instructor	21.43%	14.29%	14.29%	14.29%	35.71%

Table 9 Factors Supporting an Understanding of Course Material (Ranked in Order of Importance)

Table 9 shows that 42.86% of the students responding to the survey ranked class activities as the most important item provided to help students better understand course material (number 1 being the most important and 5 being the least important), 28.57% of the students ranked the pre-class posted lecture videos as most important, 21.43% of the students ranked meeting with the instructor as most important, 7.14% of the students ranked feedback on assignments as most important and none of the students surveyed ranked quizzes as most important.

Which of the following items helped you to better understand the course material? (Rank in order of importance based on mean score with 1 being the most important) – FALL 2022	N=15
Course Elements	**Mean Score (lower value = greater importance ranking**
Class Activities	1.86
Posted Videos	2.21
Meeting with the Instructor	3.29
Feedback Provided on Assignment	3.43
Quizzes	3.70

Table 10 Factors Supporting an Understanding of Course Material (Ranked in Order of Importance Based on Mean Score)

Table 10 shows the order of importance based on the mean score of all student responses for each item. The level of importance is ranked 1 to 5 with 1 being the most important to 5 being the least important. The results show that class activities were the most important item provided to help students better understand the course material, followed by posted videos, meeting with the instructor, feedback on assignments, and quizzes in that order.

Table 11 presents the open-ended survey question responses provided by students enrolled in Fall of 2022.

Student Responses to Open-Ended Survey Questions	N=15
What did you like best about the "flipped classroom Approach?	
Always could keep ahead	
I like a flipped classroom approach because it helps me get introduced with the material we will be learning.	
The head start on the homework	
Classtime work and walkthroughs, helped me to understand and complete labs and assignments more efficiently.	
This allowed us to focus on the lab and homework and be able to better understand the topics and ask questions.	
I like coming to class, knowing what we will be going over, and being able to ask questions as we go over the assignment for the week.	
I liked walking through the lab the most. It helped me understand what was needed.	
I liked how we didn't have a long lecture every morning over stuff that we have a good background knowledge of already.	
The more available time to work on assignments in class.	
The videos we get to back on for questions!	
I think what is best about it is the fact we have the opportunity to go through the upcoming week's material to get a head start once class starts.	
More time to work on the lab assignments in class.	
What part of the "Flipped Classroom " would you like to see changed?	
Maybe one more video each week	
Maybe have a small questions assignment (5 questions) that helps you go over the information and help us with our grade in the gradebook.	
Possibly skipping the basic previous knowledge and focusing on the specific complex areas of the activities so that we actually understand the tough part of it for the exam as I don't believe the homework points matter as long as we actually understand it and can perform it on the exam.	
The only thing I don't care for is trying to stay on top of the pre-class lecture, but it helps to be able to go back and review it when needed.	
I would like to see a small part of the assignment worked out prior to class. This would allow us to put the words being said to the work being performed and help us be further prepared for class.	
I feel like there was a lot of lecturing going on even though it is a flipped class.	
I liked going through the problems, but when you go through the whole lab at the beginning for 30 minutes, I tend to get lost and lose focus. I think it would be better to start working on the first problem and explain it as we go through each one.	
I would like to see less of the class time talking about the material already covered in the videos. If we are expected to watch the videos in class, then we should be able to use all available class time to work on the assignment.	
I think we should have more details on the video! While solving problems.	
I would like to see the lecture portion be a little quicker to get started on the lab sooner.	
Maybe, at the beginning of class like how we started the semester, you could take like 10-20 minutes going through the key points of this material and maybe give more information to get a better view overall.	

Table 111 Student Responses to Open-Ended Survey Questions

Table 11 was provided to capture the students' perspectives of the pros and cons associated with utilizing a flipped classroom approach in their own words while offering additional support for the responses associated with a Likert scale reported in the previous tables.

Table 12 presents the students' responses to the questions identified in the Canvas survey regarding the implementation and use of a flipped classroom approach in the construction cost-estimating course and faculty-student interaction.

Canvas Survey of Faculty-Student Interaction – FALL 2022				N=16
Survey Questions	**Strongly Agree**	**Agree**	**Disagree**	**Strongly Disagree**
The instructor made time outside of the classroom to respond to emails, and phone calls or to meet with students to offer additional support.	56%	44%	0%	0%
I took advantage of opportunities to meet with the instructor outside of class.	25%	31%	44%	0%
I wish I would have asked more questions during lab time or met with the instructor outside of class for additional help.	25%	56%	19%	0%
The feedback from the instructor helped me to better understand the material	44%	50%	6%	0%

Table 122 Canvas Survey of Faculty-Student Interaction

The utilization of a flipped classroom approach to increase student engagement also extends to the interaction between the instructor and the students, developing a positive faculty-student relationship. This positive (or negative) faculty-student relationship continues to develop in and outside of the classroom with each interaction. Table 12 represents both sides of the relationship including instructor availability and feedback as well as the student's decision to engage the instructor. 100% of the students participating in the Canvas survey agree that the instructor made time outside of the classroom to respond to or meet with students. 94% of the students agree that the instructor's feedback helped them to better understand the material. Additionally, only 56% of the students chose to meet with the instructor outside of class, while 81% of the students wish that they had asked more questions in class or chose to meet with the instructor outside of class for additional help.

Table 13 presents the direct assessment of students enrolled in the construction cost estimating course Fall of 2021 and Fall of 2022. A total of 22 students were enrolled in Fall of 2021 and a total of 17 students were enrolled in Fall of 2022.

Pre/Post Intervention Achievement (Direct Assessment) FALL 2021 &FALL 2022 Enrollment					**N** (FA21) **=22** **N** (FA22) **=17**
Fall 2021					
Midterm Exam Points	Midterm Exam %	Final Exam Points	Final Exam %	Final Project Points	Final Project %
115/150	76.67	75.94/100	75.94	120.87/150	80.58
Fall 2022					
Midterm Exam Points	Midterm Exam %	Final Exam Points	Final Exam %	Final Project Pts	Final Project %
120/150	80.35	84.05/100	84.05	124.59/150	82.98

Fall 2021				
Lab %	Homework %	Quiz %	Total Grade %	
86.58	87.82	87.25	81.97	
Fall 2022				
Lab %	Homework %	Quiz %	Total Grade %	
96.22	85.39	85.09	85.22	

Table 133 Pre/Post Intervention Achievement (Direct Assessment)

A two-sample t-test was performed on each individual assessment tool resulting in no statistical significance when comparing the population of students enrolled in the construction cost estimating course in Fall 2021 and Fall 2022. Table 13 shows improved scores for the midterm exam, final exam, final project, labs, and final course grade post-implementation of a flipped classroom implementation. Table 13 also shows lower scores for homework and quizzes post-implementation.

Discussion and Implications:

This study confirms that overall, a flipped classroom approach had a positive impact on student learning in the construction cost estimating course. Students' responses resulted in a mean score of 3.27 out of 4 when asked "How would you rate a flipped classroom approach" with a score of 4 being the preferred approach. Additionally, 66.67% of the students responded that they prefer the flipped classroom approach to a traditional classroom approach. Over 60% of the students responding negatively to the flipped classroom approach also reported that they put inadequate effort into class preparation each week reviewing the pre-class material. Even still, 100% of the students felt that the pre-class material and course activities gave them confidence in their ability to complete the work for the course.

The results of the study also revealed that the majority of the students perceived an increase in student-to-student and student-to-faculty engagement due to the flipped classroom approach and the increased application of course material. 93.33% of the students responded that the active learning environment made them more comfortable interacting with the instructor. 56% of the students took advantage of meeting with the instructor outside of normal class times while 81% of the students responded that they wish they would have asked more questions during class time and taken advantage of the additional help offered outside of class time.

Another focus of the study includes the best use of class time. 100% of the respondents agree that the flipped classroom approach proved to be a better use of time including pre-class material and increasing active learning activities during class time as well as allowing students to get a jump start on assigned work. In contrast, 33.33% of the students still would prefer the pre-class material to be taught live during regular class time. This introduces the dilemma that classes are scheduled for specific increments of time and that these limits prevent instructors from covering all aspects of the material in detail during class time. Instructors must balance presenting introductory background material with deeper learning through applied active learning

experiences. Student workload was also examined, balancing increased pre-class work with the completion of guided assigned work during class time. 60% of the students agreed that the pre-class material increased the out-of-class workload when viewed in isolation, but 80% of the students felt that the pre-class workload was balanced with the ability to complete a larger percentage of assigned work through guided activities during class time.

Students also recognized the increased class activities and posted videos as the most important elements responsible for their understanding of course material when compared to other elements such as meeting with the instructor, assignment feedback, and course quizzes. Class activities, which positively impacted student-to-student and student-to-faculty interactions provided the opportunity for the instructor to offer immediate feedback and further instruction to students while not all students took advantage of meeting with the instructor outside of class time. Quizzes were also used as a small-scale tool to improve individual skill sets and reward pre-class work as opposed to class activities building on larger concepts and the culmination of skills used to produce construction cost estimates.

Direct assessment was also used to measure student achievement and the impact of implementing a flipped classroom approach in the construction cost-estimating course. Data was collected from the Fall of 2021 prior to the implementation of a flipped classroom and from the Fall of 2022 post-implementation. When examining the results, students introduced to a flipped classroom environment showed improvement in their midterm and final exam, final project, and overall course grade when compared to students that did not experience a flipped classroom, supporting increased achievement and meeting expected course outcomes. Lab scores also improved due to the increased class activity and student engagement during class. Homework completed outside of class time dropped as a result of several students not completing pre-class material. Quizzes also dropped as a result of take-home quizzes being moved to in-class quizzes to better measure student mastery of the material. Though overall the results proved to be positive, analysis of the data revealed that the implementation of a flipped classroom had no statistical significance. The authors believe that this may be due in part to the small population considered for the study and that a larger population may provide more evidence of the associated improvement in the construction cost estimating course as it relates to utilizing a flipped classroom approach.

Conclusion

Overall, the study revealed that the implementation and use of a flipped classroom approach in the construction cost-estimating course had a positive impact on student achievement and that the majority of students benefited from the flipped learning environment. Pre-class material still needs to be tailored to increase student participation and review of material prior to in-class activities. The increased class activity and student-to-faculty engagement also fostered an improved student-faculty relationship in and outside of scheduled class time. Based on student comments, a short recap of pre-class material as an overview at the beginning of class would be beneficial to reinforce pre-class material and its direct connection to in-class activities. Supplementary direct and indirect assessment data will also be assessed for the same cohort of students when students complete their senior capstone project at a later date. It is the authors'

intent that this study provides knowledge for construction programs and the effectiveness of a flipped learning approach in supporting student engagement and learning.

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