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Observation of teaching approaches in two undergraduate civil engineering synchronous remote classrooms

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ABSTRACT
Background: *The sudden switch from in-person instruction to remote instruction during the 2020 pandemic was difficult for engineering instructors and students, especially in practice-based courses as there were limited hands-on activities, which are vital for reinforcing theoretical concepts to the students.*
Purpose: *This observational study investigated how civil engineering students experienced the impact of the shift to remote instruction on active learning, and the way that the experience affected the students' learning process.*
Method: *We employed a convergent parallel multi phased mixed method design to explore the phenomenon. The Classroom Observation Protocol for Undergraduate STEM*

(COPUS) instrument was used to observe two 12-week long courses in the 2020 summer session. Instructors of the two classes were interviewed. A focus group discussion was carried out with seven students. A two cycled inductive analysis process was used to generate themes from the qualitative data. COPUS data were used to visualize how class sessions were utilized by instructors and students. Kolb's Experiential Learning Theory was used to guide the study.

Results: *The data of this study showed that, the faculty lectured for more than half of the class time. Also, the data showed the students were self-motivated inherently through the courses.*

Conclusions: *Findings showed that student-centered instructional practices motivate students. Interview data showed that there was demotivation for students from the teacher-centered approaches exhibited in the class sessions. We provide suggestions to promote student collaboration, active learning, and student engagement in a remote classroom.*

Keywords: Synchronous teaching, Remote learning, Active learning, COPUS.

Undergraduate engineering student success has been a concern for experts in undergraduate engineering courses (Case et al., 2013) since engineering courses have abstract course content which require a student-centered teaching approach such as active learning. Engineering instructional practices that lack student engagement activities, and insufficient prior lesson activity preparation of the instructors are some features that lead to unsuccessful student outcomes (Baillie & Fitzgerald, 2000; Ohland et al., 2008; Zhang et al. 2004). A major problem for undergraduate engineering courses is the predominant, traditional mode of instruction, that is teacher-centered leading to lecture-based instructional practices (Bonner et al., 2020). We know that the amount of learning that engineering students can attain in the classroom environment depends mostly on the teaching approach adopted by the instructors (Velasco, et al., 2016). Active learning pedagogy encourages students to be active, taking charge of their learning process, by engaging in conceptual discussions as the instructor acts as a guide in the class sessions. For administrators and faculty to fight the high dropout/withdrawal/failure (DWF) rates in undergraduate engineering students, active learning pedagogy should be considered for instructional methods. Undergraduate engineering instructors should include more active learning methods in delivering their courses to enhance undergraduate engineering students' educational experiences.

Active learning pedagogy has shown the ability to increase students' learning gains when compared to traditional lecture-based pedagogy (Owolabi, 2017). Active learning pedagogy aims to transform the students from being passive listeners to engaged student learners (Owolabi, 2017). For example, the students in an active learning environment are encouraged to pose conceptual questions, while also engaging in peer-to-peer constructive discussions in class guided by the instructor. Research has also revealed the need for effective undergraduate engineering instructional practices that fosters students' divergent thinking skills, knowledge making, and creative skills, which are often lacking from undergraduate engineering courses (Bonner et al., 2020). Hence, teaching engineering remotely and in a pandemic presents challenges to engineering teachers and students.

The start of the 2020 pandemic in the U.S, brought emergency remote teaching to teachers across colleges. Both instructors and students were affected by the drastic change of teaching and learning approach. Instructors teaching college engineering faced specific challenges teaching students in a pandemic because of the applied nature of engineering. However, teaching engineering involves teaching students with hands-on, engineering design or inquiry-based contents which encourages the students in developing problem solving and critical thinking abilities (Bourne, 2005). Engineering teachers in face-to-face classrooms achieve this by employing active learning approaches to teach critical thinking and problem solving (Lima et al. 2017). This was particularly challenging for college teachers teaching engineering remotely and in a pandemic. Employing limited to no active learning remotely will lead to limited teacher guidance with the students which can lead to insufficient metacognitive and cognitive growth for the students' learning process (Brod, 2021). Engineering teachers who taught during the pandemic were forced to create approaches to teach quality engineering remotely. Considerably fewer researchers have investigated active learning approaches in undergraduate civil engineering classes during the pandemic.

This paper presents results of what instructors and students were doing in the classroom during a 12-week summer session, describing how actively students were engaged in the classrooms. Also, this paper presents the students' and instructors' perspectives on active learning in a remote learning environment. The paper further presents insights on active learning from 30 civil engineering students in Summer 2020 who participated in two compulsory classes during a pandemic. We also present insights from the two teachers who taught the two classes in the summer 2020 remotely. We interviewed the teachers three times through the 12 weeklong classes providing depth into the challenges the teachers faced by teaching college engineering remotely. We framed this study using

Kolb's experiential learning cycle. We conclude this paper with what was learned from the unprecedented event of teaching engineering college students remotely in a pandemic and provide recommendations for effective remote active-learning classrooms.

Literature Review

In the decades past, engineering educators and administrators have been working to establish effective standards for engineering instructional practices (Wu et al., 2020). They strive to establish research findings, effective practices, and weigh in on lessons learned. Nevertheless, engineering educators still struggle to give a perfect procedure for ensuring instructional practices that equip engineering students for the current challenges of the engineering profession (Grand Challenges for Engineering, 2016). Engineering education researchers have validated the efficacy of active learning pedagogy over teacher-centered traditional instructional methods. Unfortunately, transferring of empirical educational research into instructors' instructional practice has been slow (Shekhar & Borrego, 2017). For the U.S to attract, retain, and graduate efficient students in engineering, we must improve the students' educational experiences and give more practical and relevant knowledge to the students. The problem for engineering education is in the shortcomings of the traditional teacher-centric nature of the engineering instructional practices where the faculty fails to demonstrate the real-world connections between conceptual topics throughout the engineering curriculum (Maciejewski et al., 2017).

The American Society of Civil Engineers (ASCE) reports that higher education institutions are mostly responsible for delivering foundational concepts, skills, and knowledge to undergraduate civil engineering students for them to get a degree in civil engineering (Cai et al., 2019).

Civil engineering is taught at universities that produce successful students who venture into rural and urban construction industries (Burgher, 2014; Hattinger, Spante & Ruijan, 2014). Civil engineering at most four-year colleges comprises geotechnical engineering, management science and engineering, construction engineering, and environmental engineering. Also, across the globe, civil engineering as a higher education discipline has continued to expand to enroll more students. In 2016 the US awarded 11,464 bachelor's degrees. Between 2017-2018 in the U.S, civil engineering awarded 12,221 bachelor's degrees (Prince, 2004). This increased enrollment should influence changes in civil engineering undergraduate instructional pedagogies for appropriate instructional pedagogy to support the increased enrollment.

Active Learning Pedagogy

Active learning is defined as an instructional practice where students read, write, discuss, or engage in solving problems (Prince, 2004). Students in active learning are engaged in tasks that are higher order thinking such as analyzing, synthesizing, and evaluating (Bonwell, et al., 1991). Hence, active learning is an instructional activity where students are doing things and thinking about what they are doing. Prince et al., (2020) substituted 'active learning' with 'active student engagement'. This study also adopts this switch to include all the instructional methods covered in the definition of Spradely (1980) as active student engagement as an instructional method in which all students are asked to engage in the learning process (Bonwell, et al., 1991). This is to evade the ambiguity of the differing definitions of the term active student learning. This is also adopted because "active engagement" is more practical with asynchronous online instruction, where "in-class activities" in several other definitions as summarized by Benson et al., (2010) are meaningless (Krahenbuhl, 2016).

Active student engagement in the engineering discipline has been identified in numerous forms over the years. They range from simple tasks (e.g., students momentarily deliberating or having conversations about an instructor's assigned topic) to courses designed as team activities or case studies for student participants to continuously engage with and learn from one another (Kolb, 1984; Krahenbuhl, 2016). Applying active student engagement instructional pedagogies attempt to improve student participants' independence, problem solving skills, and critical thinking abilities. Furthermore, active student engagement pedagogy is an instructional technique grounded in experiential learning theory, which this study uses as a framework to guide the study. The fundamental characteristic of active student engagement pedagogy is to mix the "students' learning activities with the practical application of engineering and give full play to the students' creativity and initiative" (English, 2019). Undergraduate civil engineering instruction that embraces this pedagogy practices the student-centered approach where the instructor plays the role of an organizer and a guide through the students' learning process (English, 2019).

Several pedagogical methods that integrate active student engagement pedagogy involve the following: experiential pedagogy, hands-on learning pedagogy, problem-based learning, flipped classroom learning, case-based learning, internships/industry engagement, and field experience. In evaluating the efficiency of these various pedagogies, scholars' approaches comprise measuring the students' conceptual understanding and attitude after using an instructional pedagogy. An example is the research of Eren-Sisman et al. (2018) where the authors compared undergraduate engineering students' conceptual understanding with students using active student engagement pedagogy and students using traditional learning pedagogy. The researchers concluded that after controlling the students' university entrance scores, trait anxiety scores and pre-test scores of both the general chemistry concept test and state anxiety, the students that used the active student engagement model were more effective in improving the conceptual understanding in the students' knowledge making than the students without the active student engagement model. The students' experience of constant engagement and peer learning from Eren-Sisman et al. (2018)'s study is a good step in the direction of knowledge making.

Generally, studies done on engineering pedagogy and its effect on engineering students have generally described students' high-performance rates, high satisfaction rates, and measured student outcomes in understanding engineering concepts. Furthermore, in general, studies on active student engagement pedagogy in engineering have reported positive gains in terms of student retention rates, student satisfaction, and an increase in problem solving skills of engineering students [Bhagat, 2016; Chao, 2015; Chen; 2014; Huang, & Hong, 2016; Owolabi, 2017; Strayer, 2012]. However, there are few studies that describe or explore the details of existing active student engagement pedagogy in undergraduate civil engineering classes (Kerr, 2015; Lee, 2018). There is therefore a need for case studies with more details that provide evidence of the potential effectiveness of active student engagement pedagogy in undergraduate civil engineering classes (Kerr, 2015; Karabulut-Ilgu, 2018; Lee, 2018).

Engineering Faculty Adoption of Active Student Engagement Pedagogy

Although there has been valid empirical research on the effectiveness of active student engagement learning over traditional instructional approaches, diffusion of this education research for instructor adoption has been slow (Shekhar, & Borrego, 2017). Studies have also shown that instructor professional development workshops encourage instructor adoption of active student engagement by increasing the pedagogical knowledge of the instructors. The research of Lattuca et al. (2014) showed high levels of positive association between participating in professional development workshops and instructors' adoption of active student engagement practices. The National Effective Teaching Institute (NETI), which provides professional development workshops for engineering instructors, stated that instructors are slow to adopt active student engagement approaches because the instructors have difficulties in selecting active student engagement activities and more importantly, the students resist these activities (Reid, 1999; Ssemakula, 2001). Although studies highlight that instructors' conceptions about teaching affects the instructors' instructional approach, students' resistance is the main barrier for adoption of active student engagement (Cutler, 2012; Finelli et al., 2013; Froyd et al., 2006; Dancy & Henderson, 2010; Marra, 2005).

Suggestions to Avoid Remote Teaching Fatigue

Below are some suggestions to avoid remote teaching fatigue or video conferencing fatigue and to make remote learning active for undergraduate engineering students. Some of these recommendations are similar to the recommendations given in the studies of Prince, et al., (2020). The data in this study also support these recommendations as explained in the recommendations below. Also, the ELT framework used in this study posits that for the students to attain new knowledge, they should engage in the four levels of the experiential learning cycle from receiving concrete information to testing in new situations. However, from the data in this study, the students did not attain new knowledge in the classroom. as they only experienced the first two steps of the cycle. The recommendations below will encourage teaching practices that will allow active student engagements as students engage in the four-cycle constructs of ELT in the classroom. The result of this study confirms a teacher-centered remote learning environment in the observed classrooms, hence, these recommendations given below.

1. Plan ahead for remote teaching at departmental level: The administrators of the civil engineering department used in this study, organized an active student engagement workshop for the instructors of the courses used in this study prior to resumption. Administrators and faculty in the department should collaborate to make course delivery effective. This sensitizes the instructors in active student engagement teaching. Perhaps, an assessment of instructors' comfort with implementing active student engagement and classroom observations should be done to encourage the instructors to adopt active student engagement.
2. Think- pair- share: This was lacking in the classes observed where the instructors did most of the talking. There was no think-pair-share encouraged by the instructors on screen or off screen. The instructor can start with a challenging question and give the students a few minutes to think about it by themselves (it can be introduced at the start of class, or before class begins). Instructors can create breakout rooms from the main virtual rooms where the students

can be grouped or paired to discuss the question and teach one another what they know. In these smaller breakout rooms, the students can use a whiteboard to teach one another or upload videos. After that, the students can present their results by sharing live video or in the discussion board of the platform being used.

3. Collaboration activities: In the classes observed for this study, students were not encouraged by the instructor to collaborate on-screen or off-screen. Some remote teaching applications can create team building activities in the classroom to encourage the students to connect with themselves. Other tools like Google Docs, Sheets and Slides can be used to allow multiple students to have collaborative documents, working on the same file simultaneously. Instructors can also assess the students before and after collaboration efforts to show students' prior knowledge of a concept and also, show how the students' knowledge has changed after the collaboration work.
4. Wrap up minute papers: Instructors can wrap up the class session earlier leaving out time to ask the students a key question for each student to answer in one minute. Instructors can ask the students 'what is the most important thing you learnt in the session?', 'what questions are on your mind? This would help the instructor know where the students are struggling and plan the next class session to attend to such arrears.

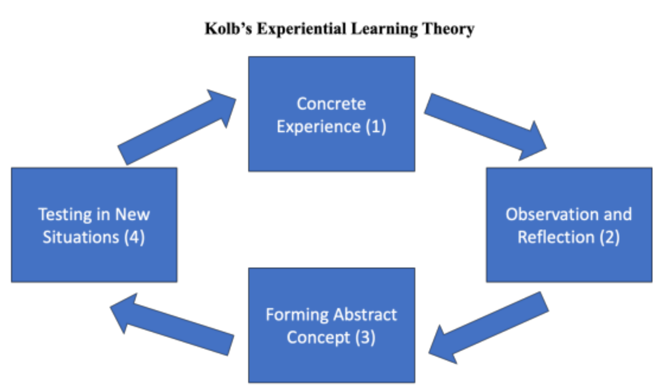
Conceptual Framework

We aimed to understand the process of how students attained new knowledge in the two courses observed using the experiential learning theory (ELT).

Hence, we wer interested in using ELT to frame how the process of knowledge making was enhanced using active learning in a remote classroom during a pandemic. The framework we employed to attain this and guide this study uses the levels of experiential learning theory to establish knowledge making in an ideal academic environment for civil engineering undergraduate students (Kolb, 1984). Experiential learning theory (ELT) by Kolb is principally appropriate to this study of active student engagement (Kolb, 1984). The theory postulates that important learning happens better when students pass through a cyclical learning procedure. The process starts with knowledge from a new concrete experience like the student being shown a piece of technology, equipment, or process followed by the student reflecting on that experience and leading to the student having abstract generalizations and conceptualizations of the experience which are tested empirically, and results in another new experience (Kolb, 1984).

Figure 1

Experiential Learning Model cycle



Purpose of the Study

Engineering professors should design their lesson plans to engage their students; teachers share responsibility with students to ensure that the students assimilate the concepts of their lesson plans (Smith et al., 2005). The purpose of this mixed-methods study was to investigate the impact of active student engagement on engineering students in selected civil engineering classrooms, which was explored using experiential learning theory principles. This mixed methods study explored the presence of active student engagement pedagogy in the selected undergraduate civil engineering core courses and the nature of the students' motivation (Connor, A. et al., 2015; Hammersley & Atkinson, 2007). The researchers explored how active student engagement is utilized in the selected undergraduate civil engineering core classes at a Historically Black College/University (HBCU). We observed the emergency pedagogical adjustments used to teach a predominantly black group of engineering students. COVID-19 pandemic is the first crisis to cause a major shift of pedagogical approach from in-person to remote teaching and learning (Gelles et al., 2020). The researchers further explored fertile academic environments for undergraduate civil engineering students to be motivated in the field of civil engineering. The results of this study help inform positive teaching praxis in engineering education.

Research Question

> How do undergraduate civil engineering instructors in two 12-week summer classes employ active student engagement pedagogy in teaching students online?

Methods

Participants

The participants in this study are students that enrolled and participated in the two selected undergraduate civil engineering classes in the session selected for this study. There were 19 students enrolled in class A and 11 students in class B. During each class, observed students ranged from seven to fourteen students as shown in Table 1. The instructors of both classes were also participants in this study as they were observed and interviewed too. Instructor A had over 25 years of full- time teaching experience while Instructor B had over 30 years of full-time teaching experience. Data were not collected in the first two weeks because the instructors explained that they will be introducing the topics and no demonstrations will occur in the initial classes. The days that data were eventually collected were the days the researcher's collecting data were available. IRB approval was obtained for gathering data from the participants in this study and students had the option to opt out of being observed.

Table 1: *Number of students that participated in each class observed for this study*

WEEK	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Instructor A (n=19)	N/A	N/A	13	11	N/A	10	9	N/A	11	N/A	N/A	N/A
Instructor B (n=11)	N/A	N/A	11	11	7	9	11	11	N/A	11	10	11

Research Approach

The approach adopted for this study is a convergent parallel multiphase mixed method design (Creswell, 2013a; Creswell & Plano Clark, 2011; Gall et al., 2010). This approach was employed to answer the research question. The approach involved interviews with the instructors teaching the classes (beginning of the semester, mid-semester, and end of semester), virtual observations, followed by qualitative focus group discussions. This methodology was adopted because using qualitative and quantitative methods provided richer insight into the phenomenon in this study (Creswell, 2015). The multiphase mixed methods design adopted allowed the researchers to collect data at several time frames, one point concurrently and at another point sequentially. The data sets were analyzed independently with the classroom observations analyzed first using pie charts to describe the results. The last data to be analyzed were the instructor interviews and the student focus group discussion using the inductive content analysis approach. DEDOOSE software was used to facilitate the coding and generating of themes from the qualitative data. The results were compared, triangulated and converged to give a holistic interpretation and findings of this study. (Creswell & Plano Clark, 2011). For example, the pie charts from the observations were used to explain some of the themes generated from the qualitative data.

Classroom Observation Protocol for Undergraduate STEM (COPUS)

The Classroom Observation Protocol for Undergraduate STEM, (COPUS) was used to observe two 12 weeklong summer courses in remote classrooms, documenting what the students and the instructors were doing in the remote classrooms (Smith et al., 2013). COPUS was selected to observe the classrooms because it was the only instrument suitable at the time data were gathered (other instruments were Reformed Teaching Observation Protocol RTOP, Teaching Dimensions Observation Protocol TDOP,) that allows the researchers to describe instructional practices taking place in the classroom without making any judgment on whether or not the practices engaged in the classroom are effective or following a particular learning style or teaching pedagogy (Smith et al., 2013). The authors were particularly interested in classes with laboratory components. The two selected courses were eventually chosen for having a laboratory component and having relatively large enrollment for summer courses at the selected institution. The two data sources were coded separately and then themes were generated and converged. The COPUS instrument is designed to describe the instructor and student classroom actions; however, it is not intended to be linked to any external criteria (Smith et al., 2013). Thus, the major standard for validity is that observers with the proposed background (STEM teachers) see the instrument as describing the full range of normal classroom activities of STEM students and instructors (Smith et al., 2013). The instrument described classroom behaviors in two-minute intervals throughout the duration of a 50-minute class session. It does not require observers to make judgments of teaching quality, and results can be summarized in graphical forms. COPUS is limited to 25 codes in only two categories ("What the students are doing" and "What the instructor is doing") (Smith et al., 2013). The observer, after training, observed the two remote classrooms and coded what she observed every two minutes. To determine the prevalence of codes in various remote classrooms, the codes in each category were added for each class session of all sessions observed and then divided by the total number of codes recorded that day. The results are visualized in the form of a pie chart.

The features of the protocol for this study included constructs in COPUS. For instance, during the observations, space was addressed within the context of how participants used it during the remote classroom activities/tasks. In this study, there was no limit to how COPUS was used to gather data during observations; several constructs were combined to show the complexity of the context/environment in which the participant group functioned together to learn (Smith et al., 2013). An example of this is when the instructor is lecturing and within the same two minutes is answering questions, then two codes are coded in the same time frame. When adopting the instrument online, the researchers tried to observe similar features that students and instructors were doing in-person at the time data were gathered. For example, when students clicked the hand raise function on zoom and the instructor called on them to answer a question. This was noted as the code students asking questions (SQ). Also, listening encompasses everything else the student is doing if they are not performing any other attribute of the COPUS instrument, hence, in an online learning environment, in order to fully engage students, the percentage of listening should be drastically reduced because all other activities are observable and inclusive as active student engagement (O. Owolabi, personal communication, April 16, 2021).

Experiential Learning Theory (ELT) as employed in this study presents a holistic approach to the students' learning process; a part of the COPUS instrument presents how students spend their time in the classroom (Sternberg, & Zhang, 2001). Using ELT to view how students spend their time in the classroom helped the researchers to explore the learning process of students in the classroom and knowledge making process. Since ELT is all about students having experiential learning, using COPUS to observe classroom behavior will expose what forms of experiential learning takes place in the classroom that can lead to new knowledge making. The diagram below shows the flow of this study's convergent parallel multiphase mixed method design to simply organize the process of data collection and analysis in this study. (Attride-Stirling, 2001).

Theme Generation Process

The data used for generating themes were obtained from the three separate interviews done with the two instructors and the focus group discussion done with the seven students from both classes. Initially, about 25 themes with some of the themes having sub-themes were identified in the coding process. Thereafter, the researchers performed a deliberate procedure of linking, refining, and defining the themes. This process also included the researchers' merging themes that were redundant or repetitive, and changing some themes into sub-themes. For example, codes like 'Virtual Lab Motivated the Students in Learning the Concepts of the Course' which was a major theme was changed to a sub-theme of 'in-person classroom preferred over remote classroom.' Finally, the process produced a total of four parent themes with some of these themes having up to eight sub-themes. The themes generated from the qualitative data are listed below, with sample excerpts.

Figure 2
Methods Flow Chart

Focus Group Discussion

Given the focus of the study, focus group discussion was employed with seven students from both classes observed using an open-ended interview protocol. According to Longhurst (2003), a semi-structured focus group discussion is a verbal interchange where one person, the interviewer, attempts to elicit information from other persons by asking questions. The aim of the researchers was to minimize influencing/interfering what was said as much as possible by facilitating an open expression of the participants' perspective of the phenomenon (Hammersley & Atkinson, 2007). The students were asked to recount specific class sessions where they did active student engagement learning. As Polkinghorne (2007) clarified, personal descriptions of life experiences may give knowledge about ignored, but significant, parts. The researchers cross checked with the participants, so they confirmed they had recorded the data accurately; this was to avoid errors in data gathering (Kivunja & Kuyini 2017). An incentive was offered for participation in the focus group discussion. The researchers raffled off one $50 Amazon gift card for one of the seven students that participated in the focus group discussion.

Data Analysis

This study employed tables, and pie charts to describe its quantitative data. These charts were used to explore the data gathered in this study (Creswell, 2013b). Also, these measures were used in addressing this study's research question, using pie charts to summarize the observations of the selected courses. Also, we answered the research question with themes generated from the qualitative data for a meaningful analysis, the researchers created a thematic network consolidating of the qualitative data from several sources. This is done to explore and understand the significance of the phenomenon in this study (Attride-Stirling, 2001).

Inductive Qualitative Content Analysis Approach

Inductive qualitative content analysis was used to generate themes from the data of this study (Elo & Kyngas, 2008). The data were coded identifying active student engagement features that manifest from the data, labeling these sections. Descriptive labels were assigned to each unit of meaning and then analytic categories were developed. A sorting stage followed the initial coding stage, re-focusing the codes, merging them into themes. In presenting the results of this study, the researchers synthesized and streamlined the data into themes. For example, a theme titled 'Virtual Lab Motivated the Students in Learning the Concepts of the Course' became a sub theme instead of a major theme. The analysis of this study identified key themes in the data that described active student engagement pedagogy and the relationship among these key factors (Saldaña, 2011). The experiences of the students and instructors were analyzed. From the analysis, themes were generated to explore what happened in the undergraduate engineering remote classrooms observed. (Creswell, 2013b).

Results

Findings from this study show that one instructor utilized active student engagement approaches, while the other instructor used little to no active student engagement approach in the remote classrooms. Also, an analysis of the theme 'Instructor Equipped to Teach using Active student engagement, but Fails to Maximize its Opportunities', indicates that adoption of active student engagement by a university instructor is dependent on the instructor as a person. This corroborates with the findings of Shekhar & Borrego, (2017)'s study, that transferring of empirical educational research into instructors' instructional practice has been slow, a reason for this is due to individual instructors' attitude to change. Also, the mindset of the instructor determines adoption of an active student engagement approach, and instructors with a fixed mindset may not be open to active student engagement approaches. This also aligns with the result of Aragon et al. (2018) where they concluded that instructors with "higher fixed mindsets were less persuaded that active-learning strategies were a good idea and less likely to implement the teaching practices" (p. 1).

The two classes selected were observed in order to record what the instructor and students were doing in a 50-minute class session.

Classroom A and students A

Instructor A's class was a structural analysis content class that had a laboratory component. The lab was introduced to the students in a class session, and the students were requested to complete the labs individually, outside of class time. Instructor A's course was designed to give the students the ability to analyze statically determinate and statically indeterminate structures. The course was also designed for the students to learn how to apply the various classical methods of structural analysis in determining deflections, internal forces, and external support reactions for beams, trusses and frames. At the end of the session, the students were to be able to do the following:

- Define basic structural engineering terminology.
- Apply Newton's laws of force equilibrium to determine axial forces, shear forces, and bending moments in statically determinate beams, trusses, frames, arches, and cables.
- Apply calculus and the principle of virtual work determine displacement in statistically determinate beams, trusses, and frames.

- Identify symmetry, antisymmetric, degrees of indeterminacy, and degrees of freedom in beams, trusses, and frames.
- Analyze statically indeterminate beams, trusses, and frames by flexibility method.
- Analyze beams, trusses, and frames by the stiffness method.
- Analyze beams and frames by moment distribution.

The pie chart and table 2 analysis below show how the students and instructors spent their time in several 50-minute class sessions. Both classes were synchronous class sessions having set time and set days for students to log on and join the virtual classroom.

Figure 3

Descriptions of the COPUS student and instructor codes.

1. Students are Doing

L Listening to instructor/taking notes, etc.
Ind Individual thinking/problem solving. Only mark when an instructor explicitly asks students to think about a clicker question or another question/problem on their own.
CG Discuss clicker question in groups of 2 or more students
WG Working in groups on worksheet activity
OG Other assigned group activity, such as responding to instructor question
AnQ Student answering a question posed by the instructor with rest of class listening
SQ Student asks question
WC Engaged in whole class discussion by offering explanations, opinion, judgment, etc. to whole class, often facilitated by instructor
Prd Making a prediction about the outcome of demo or experiment
SP Presentation by student(s)
TQ Test or quiz
W Waiting (instructor late, working on fixing AV problems, instructor otherwise occupied, etc.)
O Other – explain in comments

2. Instructor is Doing

Lec Lecturing (presenting content, deriving mathematical results, presenting a problem solution, etc.)
RtW Real-time writing on board, doc. projector, etc. (often checked off along with Lec)
FUp Follow-up/feedback on clicker question or activity to entire class
PQ Posing non-clicker question to students (non-rhetorical)
CQ Asking a clicker question (mark the entire time the instructor is using a clicker question, not just when first asked)
AnQ Listening to and answering student questions with entire class listening
MG Moving through class guiding ongoing student work during active learning task
1o1 One-on-one extended discussion with one or a few individuals, not paying attention to the rest of the class (can be along with MG or AnQ)
D/V Showing or conducting a demo, experiment, simulation, video, or animation
Adm Administration (assign homework, return tests, etc.)
W Waiting when there is an opportunity for an instructor to be interacting with or observing/listening to student or group activities and the instructor is not doing so
O Other – explain in comments

Table 2: *Distribution of student time in Instructor A's (excludes weeks for during which no data was collected)*

WK # (# OF STD)		% OF L	% IND	% WG	% ANQ	% SQ	% SP	TOTAL
3 (13)	13	62.5	5	5	15	12.5	0	100

4	11	59.5	4.8	0	16.7	19	0	100
6	10	67.6	0	0	8.1	24.3	0	100
7	9	69.4	0	0	25	5.6	0	100
9	11	60.9	0	7.5	19.5	9.7	2.4	100
AVG.		63.98	4.9	6.25	16.86	14.22	2.4	

Table 3: *Show how Instructor A spent their class time in five class sessions*

WK#	# STUD.	% LEC	% FUF	% PQ	% ANQ	% MG	% 1O1	DV	ADM	TOTAL
1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
3	13	64.9	1.6	19	6.3	0	0	1.6	1.6	100
4	11	64.6	2.6	17.1	9.2	2.6	3.9	0	0	100
6	10	55.7	0	14.3	12.8	0	0	11.5	5.7	100
7	9	78	0	15.6	4.6	0	0	0	1.8	100

9	11	72.2	0	16 .9	4.6	0	0	0	6.3	100
AV G.		67.0 8	2.1	16 .5 8	37.5	2.6	3.9	6. 5	3.8	

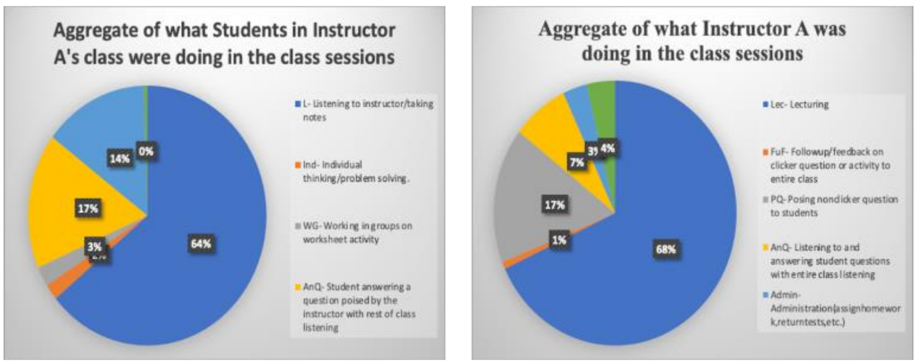


Figure 3: Aggregate percentage of what Classroom A did in five class sessions.

Classroom B and Students B

According to Instructor B’s syllabus, the class was designed to introduce the students to the planning and design of elements of water treatment plants and elements of wastewater treatment plants. The course was also designed to expose the students to the design of sewers, water distribution, and system hydraulics. The laboratory for the course was designed to apply general chemistry to sanitary chemical analyses, which includes the various forms of solids, pH measurements, and salinity. Furthermore, the laboratories were designed to expose the students to the use of atomic absorption spectrophotometers. The prerequisite for the course included general chemistry for engineering students, general chemistry for engineering students laboratories, fluid mechanics, and math calculus classes. The students after the course were expected to know the following:

● Recognize the fundamental units and unit systems.
● Apply the concepts of global warming potential, carbon equivalent and carbon dioxide equivalents.
● Derive and use chemical kinetics equations.
● Apply equilibrium expressions for environmental processes such as volatilization, air-water, acid-base, oxidation-reduction, precipitation-dissolution, and sorption reactions.
● Apply the law of conservation of mass to derive mass balance for steady and unsteady state environmental processes.
● Identify the chemical reactors used in environmental processes.
● Apply the first law of thermodynamics in deriving the energy balance equation for steady state processes.
● Apply the relevant mass transport equation in environmental process.
● Define BOD, ThOD, NBOD, CBOD.
● Identify and analyze the unit operations used in water and wastewater treatment plants.

The aggregate table 4 analysis below and pie chart in figure 4 show the description of how students spent their time in Instructor B's class and how Instructor B spent his time in the classroom. Instructor B had more class sessions because the instructor had three synchronous, one hour class sessions a week. Instructor B's class was also a class with lab components. However, the Instructor performed all the labs during the class sessions as opposed to Instructor A. The instructor performed the labs by demonstrating for the students to observe. The students were not asked to perform the labs alongside the instructor; however, the students could practice on the software after the class session. Hence, the labs were captured in the COPUS as the instructor showing a demonstration (D/V). This feature presented the opportunity for Instructor B and students B to adequately explore active student engagement which was sadly not the case. Also, it is important to note that Instructor B in an interview explained that they have over 30 years of teaching undergraduate engineering experience. It is ironic that Instructor B who performed the laboratories in the classroom had lower student engagement than Instructor A who left the students to perform their laboratory sessions outside of class time. One would expect more student engagement in the class sessions with laboratories in the class sessions. This confirms the assertions of some educational researchers who said that one of the problems of active student engagement is the students' resistance to active student engagement (Reid, 1999; Ssemakula, 2001).

Table 4: *Show how students in Instructor B's class spent their class time in nine class sessions*

WK#	#OF STUD.	% L	% IND	% WG	% ANQ	% SQ	SP	TOTAL
3	11	80	10	0	3.3	6.7	0	100
4	11	100	0	0	0	0	0	100
5	7	78.1	3.1	0	6.3	12.5	0	100
6	9	80.6	0	0	3.2	16.2	0	100
7	11	86.2	0	0	0	13.8	0	100
8	11	89.3	0	0	0	10.7	0	100
10	11	100	0	0	0	0	0	100
11	10	96.1	0	0	0	3.9	0	100
12	11	100	0	0	0	0	0	100
AVE.		90.033	6.55	0	4.26	10.63	0	

Table 5: *Show how Instructor B spent their class time in nine class sessions*

WK#	# OF STD.	% LEC	% FUF	% PQ	% ANQ	% MG	% 1O1	% DV	% ADM	TOTAL
3	11	92.6	3.8	0	1.8	0	0	0	1.8	100
4	11	94.4	0	5.6	0	0	0	0	0	100
5	7	65.6	1.5	5.9	3	0	1.5	15	7.5	100
6	9	71.6	0	1.6	8.6	0	0	16.6	1.6	100
7	11	58.7	0	3.7	7.5	0	0	28.3	1.8	100
8	11	47.5	0	1.8	1.8	0	0	45.2	3.7	100
10	11	100	0	0	0	0	0	0	0	100
11	10	48.1	0	1.3	1.3	0	0	48.1	1.3	100
12	11	92.6	0	0	0	0	0	0	7.4	100
AVE.		74.56	2.65	3.31	4.0	0	1.5	30.64	3.58	

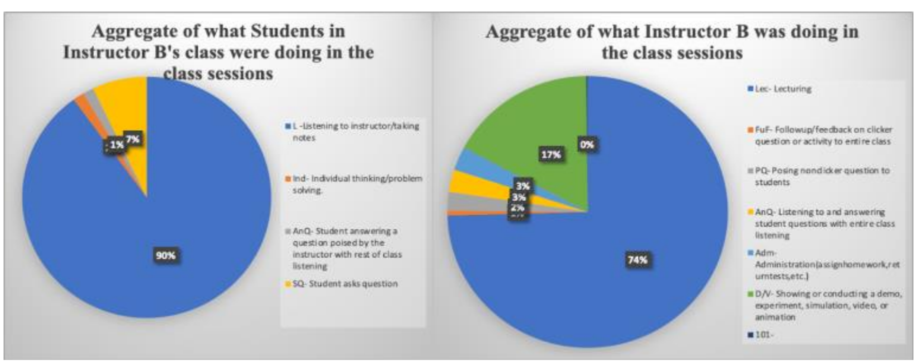


Figure 4: Aggregate percentage of what Classroom B did in nine class sessions.

Theme Discussion

There are four broad themes, with some themes having up to eight sub-themes. The themes are:

1. In-Person Classroom Preferred Over Remote Classroom
2. Instructor Equipped to Teach using Active Student Engagement, but Fail to Maximize its Opportunities
3. Students Motivated by Student-Centered session and Demotivated by Teacher-Centered Class Session
4. Students Intrinsic Motivation Drove their Motivation through the Course

The first two themes discuss the views of both instructors and students. 'Students Motivated by Student-Centered Session and Demotivated by Teacher-Centered Class Session' and 'Students Intrinsic Motivation Drove their Motivation through the Course'are specifically student themes.

In-Person Classroom Preferred Over Remote Classroom

This theme described the instructors' and students' views on in-person classroom and remote classroom. This theme had two sub-themes, 'Virtual Lab Motivated the Students in Learning the Concepts of the Course' and 'Remote Lab cannot Fully Replace In-person Lab'. This theme is linked to the experiential learning model construct 'observation and reflection'. The connection is made from how face-to-face classrooms enhance the students' observational and reflection skills. In a face-to-face classroom, students can physically see object lesson items which will in turn encourage observation and reflection of the object lesson. In this theme, the instructor explained that active student engagement thrives in a face-to-face classroom model. The instructors said they preferred a face-to-face teaching style rather than remote teaching online. The instructors described how face to face class sessions motivate the students to learn more on the concepts taught in a face-to-face classroom than in a remote classroom. Sample excerpts from teachers in this theme are:

> "I would definitely prefer to have one face-to-face, especially for undergrad. . .. Of course, face-to-face is easier like for exams and online is just crazy"
>
> "But right now I can say about the labs. Okay? The fluid mechanics labs are basically physically hands-on labs. You have to work with water you have to work with pipes you have to work with and there's no there's no shortcut to physically doing all the experiments physically handling all the equipment and it cannot be done like bio or chemistry labs or computer labs, which can be done online or virtually"

A student said:

> "but I guess just doing the simulations helped us seeing like, see, visualize it better than he would express it in lecture. But since we weren't able to physically do the labs like in person, I don't think we really got the full effect."

Instructor Equipped to Teach using Active Student Engagement, but Fails to Maximize its Opportunities

In this theme, the instructors describe how they believe in active student engagement and are equipped to teach with active student engagement pedagogy. However, the instructors failed to maximize opportunities of active student engagement activities in their remote classrooms. This was evident in the pie charts from the classroom observations. Two sub-themes for this theme are 'Instructors Challenges Using Active Student Engagement Pedagogy in Remote Classroom' and 'Limited Class Time Impedes Instructors Adoption of Student-Centered Pedagogy'. This theme is linked to the first stage of the ELT cycle 'Concrete Experience'. The instructors failed to maximize the opportunities of providing concrete information to the students using active teaching approaches so that the students can attain new knowledge. Although qualitative data from the first interview with the instructors revealed that the instructors had knowledge of a student-centered classroom, the instructors failed to maximize active teaching opportunities. The instructors attended active student engagement pedagogy workshops prior to teaching the classes and they were taught how to teach a student-centered course. In this theme, the instructors described how they will use active student engagement pedagogy in teaching from the first interview, and that they believe students gain more when the classroom environment is a student-centered one, where the students learn by doing and experiencing the concepts of the class firsthand. It was interesting to note that instructor B acknowledged that he attended an active student engagement pedagogy workshop prior to starting the semester but failed to maximize active student engagement opportunities. A student's excerpt to this theme is "I would say it was mainly PowerPoint, there were a lot of PowerPoint slides." Sample excerpts of the instructor's experience of the theme are: "Yes, I attended a workshop about designing the online course for Canvas and also how to conduct the class using Zoom." The second Instructor also said "Yeah, I did before the start taking this class teaching this course, I attended the online teaching, I had to take the course. So I had to. It was helpful because the module, I didn't honestly know how to prepare the module." However, from the observation results of the pie charts, the teachers had teacher-centered classroom sessions.

Students Motivated by Student-Centered session and Demotivated by Teacher-Centered Class Session

The students in this theme described how active student engagement classrooms motivated them in their learning process. The students further described how teacher-centered classrooms demotivated them. This theme had eight sub-themes; they are: ‘assignment-heavy course,’ ‘unsympathetic professor,’ ‘instructor reads slides only,’ ‘no active student engagement approach,’ ‘lack of teamwork activities,’ ‘teaching pedagogy demotivates,’ ‘pandemic pressure affects motivation,’ and ‘no review or study area guide prior to exam.’ This theme is connected with the constructivist learning model construct ‘concrete experience. The connection of the theme to ‘concrete experience’ is evident when the instructors fail to utilize active student engagement tasks to teach the students the concepts of the course, limiting the students’ exposure to concrete experiences. Instructors in this theme described their class session as more content-driven and more assignments given to students while the students described the class sessions as content driven, heavy assignments sessions as demotivating them to learn the concepts in the course. An excerpt of what an instructor said about this theme is: “I gave them almost I can say a very big in scope big project because I want to push them to learn one software structure analysis software.” A student said: “nothing from this class really motivated me to do much or to pursue or further civil engineering.” Another student said: “And he didn't like, influence my decisions or anything for this class didn’t to influence my decision to continue as civil engineer.” The excerpts of this theme described the classroom sessions as teacher-centered classrooms that demotivated the students. More excerpts is a student saying, “Flat rate, he didn’t use or teach the labs in class.” Another student corroborated that saying: “[the professor was] talking more closely to the theory and less to how it applies to things." A student also said an instructor gave: "six assignments in the span of one and a half weeks." Another student said: "[the professor] would just go from chapter to chapter just reading off slides, you know."

Students Intrinsic Motivation Drove their Motivation through the Course

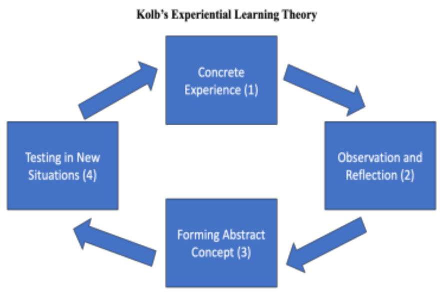
This theme described the students' experiences through the course where they described their motivation as self-driven. Findings of this study showed that in the observed remote classes, students' levels of intrinsic motivation drove the students' learning pace. This means that students with high levels of intrinsic motivation take charge of their learning process to achieve success in the classes. In this theme, students took charge of their learning process by seeking external instructors (YouTube) to learn from. This theme is linked to the constructivist learning model construct 'forming abstract concepts.' The connection of this theme to the construct is apparent when students seek external materials to learn the concepts of the course; doing this means the students took control of their learning process to get the knowledge needed for the course. This theme further describes how recorded sessions and YouTube videos were a go to resource for the students to get answers to their questions. In this theme, the students described how they got answers to their questions from the remote classroom sessions, from other YouTube tutors during homework sessions, and how some of them go back to the recorded session of their instructors. The instructors also corroborated this saying the students requested for the class recorded sessions. A sample excerpt of this theme is a student saying: "well, for me personally, I didn't feel like I could really learn much from the teacher; most of my information was coming from other sources."

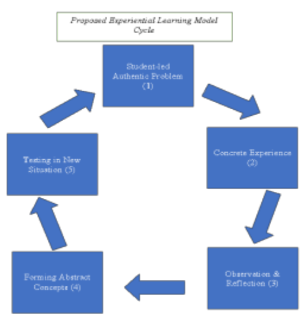
Students Intrinsic Motivation Drove their Motivation through the Course theme showed that the students' innate motivation drove their knowledge making process. Other excerpts of this theme are as follows: "Guess I do end up doing a lot of my learning, I guess through my homework and stuff like that through self-exploration." Another student said: "We pretty much had to figure everything out in our own time doing our homework assignments, or reviewing notes, lectures, whatever on our own." When asked why the students did not ask questions during the class sessions, a student said: "I guess I am somebody that can do a lot of things like periodic studying, where I'll study for a bit and then go do something else and think about it for a while." Another student said: "I'm kind of motivating myself. I honestly motivated myself the entire time" and another student said "no, it was all on me basically." A student also said, "I think all of those things are on us if we really want to do it or stick with it. The students' intrinsic motivation drove them to seek knowledge in external recorded contents. The students' drive to seek external content was to add more knowledge to what they already knew or to answer questions they had from the class sessions.

Advancing Experiential Learning Cycle in a Remote Classroom

Although Kolb and Fry (1975) suggested that the learning process can start from any point in the experiential learning cycle, they suggest that for optimal learning to happen, the process should start with 'concrete experience.' The findings of this study suggest approaches that will encourage students' engagement which may in turn lead to a student-centered environment in a remote classroom. The researchers of this study propose a new first step in the cycle of experiential learning theory. One of the findings of this study is that students were demotivated by the class sessions because the instructor read more slides than employing active student engagement tools to teach the concepts. In all the class sessions, the instructor opened the class with slide presentations explaining the concept to be taught in that class session, thereby setting the classroom environment to a teacher-centered classroom. The researchers in this study are proposing a first step in the experiential learning cycle to precede the 'concrete experience' with a starting phase 'student-led authentic problem/task.' This will be a student-led phase that will set the agenda of the classroom environment to a student-centered environment where the students start the class with an authentic problem/task. Prior to the class session, the instructor would send the students a short video on the concept to be taught for the students to watch and come to class with authentic problem questions to open the class session. This approach is similar to a flipped classroom and problem-based learning. The important emphasis in this particular approach is that the students open the class session with authentic problems and not the instructor giving an authentic problem. The data from this study show that in an online environment, the instructor starting with the 'concrete experience' phase with lectures and slides turned the sessions into teacher-centered sessions making the class session 'slide controlled' and 'boring' to the students. Another theme from this study (Students' Intrinsic Motivation Drove their Motivation in the Course) supports the students doing prior research on the concept. Most of the students said that after class they went on YouTube/recorded class sessions to find out more on the class sessions that they did not understand from the instructors teaching. Instead of the students going to search for resources after the class session, the instructor will send resources ahead of class for the students to read and come to class to open the class with an authentic problem. This first phase will make the students take immediate charge of the class session and encourage peer learning amongst the students. (Vygotsky, 1978). See figure below for proposed constructivist learning model.

Figure 4
Old and Proposed Experiential Learning Model Cycle





Discussion

The aggregate results of what both Instructors A, and Instructor B did in their class sessions show teacher-centered instructional strategies. Also, the aggregate results of what Students A and students B did in their class sessions shows passive student engagement. The data of this study further revealed that the students' engagement to stay motivated in the class was intrinsic as they were discouraged by the slide heavy class sessions. Although, students in Instructor A's class showed more active student engagement in their class sessions than students in Instructor B's class. As noted earlier, both instructors have been teaching undergraduate engineering for over 20 years. Also, in an interview, both instructors said they attended the active student engagement workshop provided for the instructors in the HBCU civil engineering department where this study took place. This was the only active student engagement workshop they had ever attended. Although organizations like National Effective Teaching Institute (ASEE) and the Excellence in Civil Engineering Education (ExCEEd) organize several professional developments for civil engineering instructors, some instructors do not have access to these programs due to limited institutional professional funds. Some institutions continue to rely on training from Centers of Teaching and Learning or occasional external speakers and institutional resources for training instructors on active student engagements.

The results from this study highlight the use of active student engagement in the undergraduate civil engineering classrooms observed. While analyzing all the different types of data gathered, the authors believe the data indicate that active student engagement is a pedagogy that can be employed in undergraduate civil engineering education to increase the student's active engagement. This can also increase engagement in the classroom, by encouraging peer to peer students' engagement, this will encourage instructors to consider more extensive student engagement activities in the classroom. Furthermore, the descriptive figures of the findings of this study are evident in the descriptive COPUS pie chart analysis given in the appendix section of this paper below, as most of the pie charts showed instructors had more lecture content than active student engagement activities. According to Smith et al. (2013) lecturing (Lec) student code is the most indicative code for passive student behavior in response to the faculty lecturing ("Lec") with or without real-time writing ("RtW"). However, the level of activity increased in class sessions with remote class laboratory sessions. Nevertheless, this analysis brings up the question, how much active student engagement in an undergraduate civil engineering class session is enough active student engagement?

Recommendations for effective remote active-learning classroom

As discussed in the introduction that active student engagement is important for successful teaching and learning irrespective of the delivery approach, we established that active student engagement is challenging in a remote setting. Going forward, depending on how the on-going pandemic plays out and how higher education institutions adapt to the pandemic, there are possibilities of continued remote /hybrid learning. Also, there are possibilities of keeping some of the active student engagement activities used remotely through post pandemic. Universities will see benefits in remote learning as opportunities in response to crisis situations, and remote learning may be an option. Hence, to encourage an active student engagement approach in remote classrooms, the instructor should incorporate several active student engagement activities (Chao et al., 2015). There are several remote learning tools and applications like polling apps, asking questions and getting answer applications, plus reading apps and group messaging applications that help the students to share, solve problems and collaborate together. The instructors will have to learn how to use these applications and be creative in adapting them in their remote classrooms. The only important thing for the instructors is to be consistent with the platform and applications they adopt so the students know where/how to go about the applications.

Conclusions

Classes observed were teacher-centered, which demotivated the students. This result helps inform undergraduate engineering teaching practices; we further provided some recommendations to encourage student engagement in engineering remote classrooms (Emiola-Owolabi, 2021). Engineering instructors should always find time to design student-centered activities in their classroom. It may also benefit engineering instructors to attend active learning workshops or professional development (Smith et al., 2013). Additionally, educational administrators should establish engineering school departmental active learning pedagogy workshops for students and their instructors. Several opportunities abound to encourage engineering students' collaboration remotely for example, students can present projects by sharing their screens and use google docs to collaborate on projects, and instructors can learn how to use active learning ideas like the breakout on Zoom and other platforms. Importantly, college educational administrators should establish effective periodic classroom observations of undergraduate engineering instructors' classrooms to measure the active learning methods employed by instructors.

Implications for Future Study

For further research, our recommendations include exploring how to increase instructors' and students' acceptance of active learning approaches in undergraduate civil engineering remote classrooms. Also, it is crucial to investigate the dynamics between the importance of content/concept teaching and having a student-centered classroom (Emiola-Owolabi, 2021). Besides, there should be more investigation on the impact of active learning pedagogies on remote large structured undergraduate civil engineering class sessions, that will improve online and in-person classroom student engagement. Furthermore, researchers should explore the application of active learning pedagogies on other undergraduate engineering classes and to investigate how active learning pedagogy is successful with specific instructors' and students' undergraduate engineering in other engineering courses. Also, more research is suggested to explore the effect/influence of active-learning instructional pedagogies on encouraging undergraduate engineering students to enroll in more engineering classes, to consider a major in engineering, and continue in engineering programs. Finally, as the engineering education society works to deliver ways of improving the undergraduate engineering course experience for undergraduate students, to decrease attrition in engineering students' majors and to graduate more engineers, further attention to the active learning approach is necessary in realizing these goals (Emiola-Owolabi, 2021).

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