2021 ASEE ANNUAL CONFERENCE
Virtual Meeting | July 26–29, 2021 | Pacific Daylight Time
Paper ID #34119

Remote and Hybrid Learning Environments: A Case for Promoting Student Engagement

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Remote and Hybrid Learning Environments: A Case for Promoting Student Engagement

Abstract:

This full research paper explored students' evaluation of the various engagement strategies undertaken by faculty at the University of Cincinnati, a large, urban, midwestern university in both a fully remote and hybrid first-year engineering design course. Socioecological (engagement in terms of social and ecological factors such as availability of resources, communication, organizational, and instructional support) and opportunity-propensity frameworks (learning opportunities and students' willingness to avail to these opportunities) were used as the theoretical frameworks that underpin this research.

In order to explore the engagement strategies used by faculty and the ways these strategies were received by the students, two surveys were developed. Two of the twenty-two sections of the first-year engineering design course were designated as fully remote while the remainder utilized a hybrid approach. In this hybrid approach, half of the students attend in-person while the other half attend remotely for the first weekly class meeting. Students then switch roles for the second meeting. Course content, in-class activities, assignments, and exams are common among all twenty-two sections, regardless of modality.

This exploratory research employed a mix of Delphi style and traditional approaches (adapting items from existing instruments) to the development of the two survey instruments: (1) a faculty survey to identify engaging strategies, and (2) a student survey to evaluate these strategies in a self-reported Likert format along with open-ended questions. This paper primarily presents the development of the two surveys and the validation of the student engagement survey using exploratory structured equation modeling technique. It only briefly presents students' evaluation of the engagement strategies as this is not the primary focus of this paper.

Background and Motivation:

Distance learning has been a staple of educational systems around the world since the 1700's [1], but has only become a major topic of research in recent decades. Distance learning has taken on many different forms over the years, starting with correspondence education, where individuals received materials and submitted work for feedback via mail services. These correspondence courses often started out as individual instructors corresponding with a select group of students, but later evolved into more organized systems with full degree offerings housed in major universities or spurring the creation of correspondence universities focused solely on this new approach to education [1].

As technology improved, it was slowly incorporated into the distance learning model. The early 1900's brought the advent of the radio and allowed for instructors to broadcast lectures to a wide audience. The use of television as a means to deliver instruction has been in use since the mid

1900's. While computers were available since the mid 1900's, they did not see widespread use in distance education until the 1990's, when sufficient telecommunications infrastructure was available [2].

Despite the initial resistance to the use of computing devices, distance learning has transitioned almost exclusively to the use of the computer and is now often referred to as online learning. However, the ways in which online learning is conducted varies greatly. The massive open online courses (MOOCs) pioneered by edX [3] allow for enrollments of hundreds or thousands of people. These courses tend to focus on single topics and typically do not lead to a degree. On the opposite end of the spectrum are fully online degree programs. These range from a few programs offered at traditionally in-person institutions to institutions focused solely on delivering fully-distanced degree programs, such as the University of Phoenix and Southern New Hampshire University.

One of the issues identified with online learning is the level at which students engage in the course. Student engagement has been linked with improved classroom learning and performance [4-6]. In a traditional in-person classroom, some of the factors that promote student engagement include providing a stimulating environment and foster social connections [7-8]. Unfortunately, these prove to be difficult to achieve in an online environment, especially the fostering of social connections. This is one of the reasons for the poor completion rate of MOOCs, namely that students are not able to stay engaged with the course and eventually drop out [9-10].

The advent of the novel coronavirus and the global pandemic in the spring of 2020 forced many institutions to reevaluate the ways in which they engage their students. Due to social distancing and other safety measures required by state and local governments, many colleges and universities around the country transitioned to either a remote or hybrid approach to course delivery for the second half of the spring 2020 semester and the fall 2020 semester. As a result, many instructors, who had no prior experience with distance learning, were forced to redesign their courses on very short notice to be delivered in a distance learning format.

At the University of Cincinnati, a large, urban, midwestern university, a common first-year engineering design course sequence is taught, which focuses on developing students' design, algorithmic, mathematical, and spatial thinking skills along with other professional skills such as written and oral communication, teamwork, and professional ethics. The course meets twice a week for two hours each and relies heavily on team-based, hands-on activities and projects to help students learn the course material. Additionally, the course uses a flipped classroom approach, where students watch assigned videos or read selected chapters from the textbook prior to attending class and spend most of class time working together in teams to solve problems or work on activities related to the topic for the day.

In the middle of the spring 2020 semester, in reaction to the spread of the novel coronavirus, the course transitioned from a fully in-person model to a fully distance-learning model. Course content was still delivered using the flipped classroom approach, but due to the limited availability of breakout room features in most of the video conferencing software available, in-class time primarily consisted of the instructor working through example problems or the students working in isolation on the problems and activities they would normally have worked with their team to solve.

Over the summer of 2020, it was decided to employ a hybrid approach to most sections of the course for the fall 2020 semester in order to still provide students with an in-person experience while conforming to classroom occupancy requirements. In the hybrid approach, the class was divided into two groups. The first group attended class in-person on the first-class period of each week while the second group participated remotely. For the second-class period, the groups switched roles with the second group attending in person and the first group participating remotely. In addition to the 20 sections hybrid sections, two fully-remote sections were taught in order to cater to those students who did not want an in-person experience or who were unable to attend in person due to health concerns or international status.

However, none of the instructors teaching the course in the fall 2020 semester had any significant experience teaching in a distance-learning environment. As a result, each instructor adopted their own approach to trying to engage both their in-person and remote learners. The purpose of this study is to try to capture what strategies instructors used to engage their students as well as how those strategies were received by the students. In order to do this, the following research questions were investigated.

Research Questions

Primary

1. What are the primary engagement strategies that are employed by the first-year undergraduate engineering faculty in a fully remote and hybrid learning environments?
2. What are the psychometric properties of the Student Engagement Survey?

Secondary

1. How did students evaluate these engagement strategies in terms of their level of engagement?
2. What were the self-evaluation of students in terms of staying engaged (affective, cognitive, behavioral) and learning propensity?
3. What challenges primarily hindered their engagement in their learning environment?

Theoretical Framework:

Engagement research has been around for decades and has been established to be an important forerunner for learning and achievement [6,11]. For this study, engagement is defined in the context of affective (interest, excitement, belonging, motivated, persistent, joy, etc), cognitive (self-directed/regulated learning, reflective, task specific-design solutions, etc), and behavioral (task completion, proactive, communication, attendance, etc) [12]. Given this social and emotional classification of engagement, this research investigated student's engagement based on two theoretical frameworks that are summarized visually in Figure 1. First is the socio-ecological framework [13], which originally was developed to understand the human development process in relation to the individual and their social or ecological context. It has also been used to examine engagement and achievement in relation to student characteristics and learning climates, like instructional support for middle and high school students [14]. In the current study, this framework examines engagement within the context of the first-year undergraduate engineering students' learning environments (hybrid and fully remote), their peer dynamics in teams or groups, and instructor /teaching assistants (TAs) interactions through the activities like discussions or questioning, to name a few.

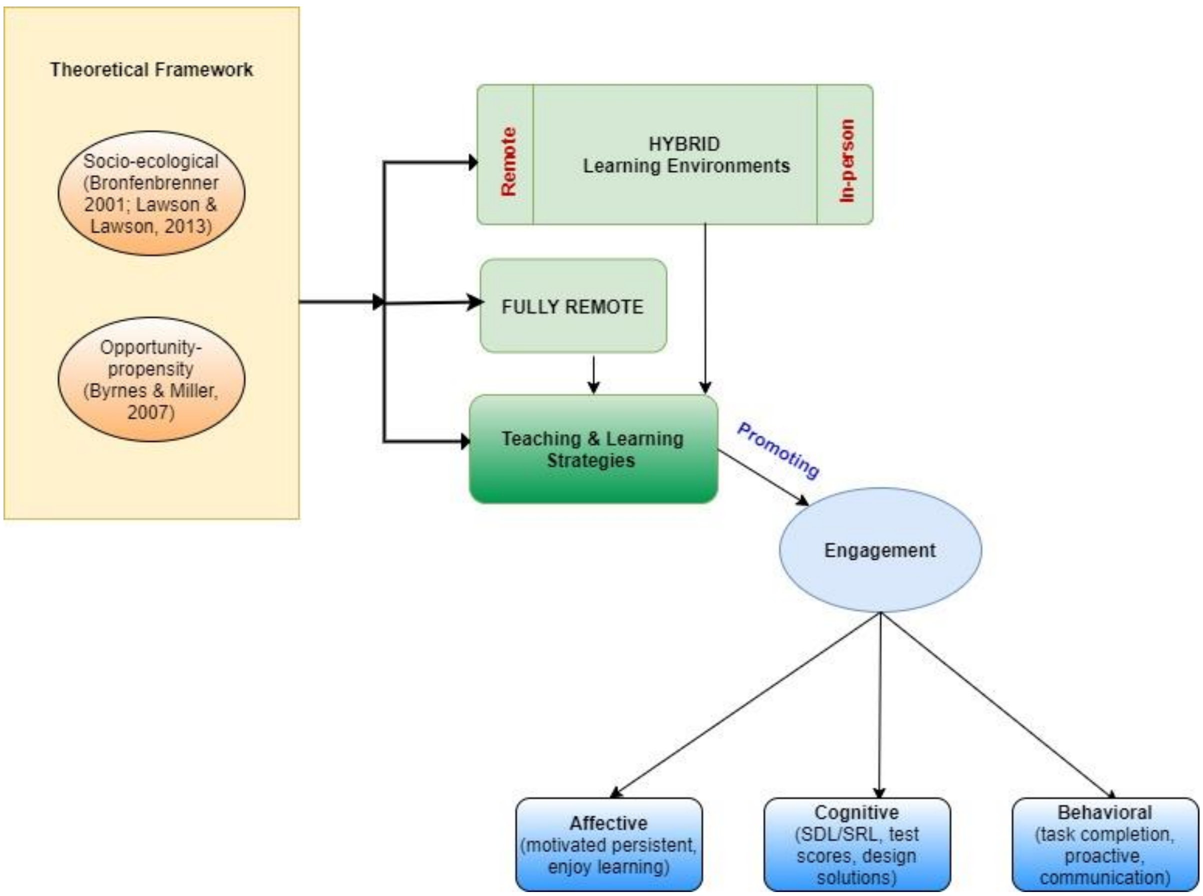

FIGURE 1: Theoretical frameworks that guide the LE and teaching-learning strategies to promote engagement

The second is the opportunity-propensity framework. This traditionally has been applied to relate achievement to the opportunities provided to learn the content, develop skills, and practice it. Additionally, it has also been applied to investigate the propensity or willingness of students to avail to these opportunities [15]. More recently the framework has been applied to examine student engagement in science for middle school students [16]. This served as an impetus for utilizing this framework in the current study. It was used to examine how likely students are to perform a certain task based on the opportunities that were presented in their respective learning environments and how that reflects their learning characteristic and learning outcome. This exploratory study uses these frameworks to illicit responses from students that serve as an evaluation of the various engagement strategies that the faculty used in both types of learning environments through the developed student engagement survey.

Methods:

Sampling and population:

This research used a purposeful sampling for reasons of convenience as one of the researchers is a faculty involved in teaching the first-year engineering course. Additionally, with the exploratory nature of this research, it was important that the chosen class be easy to access in terms of students and faculty. The class that was selected for this research was the first in a two-course, first-year engineering design thinking sequence. It was selected as it had a blend of both hybrid and fully remote learning environments and the course structure provided the use of various strategies given the new learning environments. The course, named Foundations of Engineering Design Thinking I, is taken by all first-year undergraduate engineering students. It is a 3-credit hour course with 4 studio hours. The course introduces students to the engineering professions through multidisciplinary and societally relevant content. They learn to develop approaches for understanding engineering systems and generating and exploring creative ideas and alternatives. They are introduced to concepts in creativity, innovation, engineering fundamentals, and problem-solving methodologies. Students are expected to learn, through experience, the process of design and analysis in engineering, including how to work effectively on a team. Finally, they were expected to develop skills in project management; sustainability; written, oral, and graphical communication; logical thinking; and modern engineering tools (e.g., Excel, Python, LabVIEW, MATLAB, Visual Basic, CAD, Rapid Prototyping) [17].

For a typical class period, students were expected to complete a pre-work assignment (usually in the form of a video) that covered the fundamentals of the day's topic as well as a short quiz administered through the Learning Management System (LMS) to encourage students to complete the pre-work. In-class time was divided between instructor or graduate teaching assistant led discussions and examples related to the material, team-based activities, and a check-for-understanding (CFU) quiz. A homework assignment was assigned at the end of each week covering the preceding material.

The pre-work video assignments were designed to cover the fundamental concepts related to the given topic. The videos consisted of a mixture of content, examples, and exercises. Some also included embedded quizzes to allow students to gauge their understanding of concepts that did not lend themselves to exercises. The pre-work quizzes focused on the major concepts the students should have understood from the pre-work at a very basic level.

The team-based activities consisted of a set of problems on which the students would work in their 3-4 person teams. Each task in the activity increased in difficulty and there were more tasks than it was possible to complete in a given class period to both ensure that stronger teams would not run out of things to do and to provide additional opportunities for practice, as the activities and solutions were posted on the LMS following each class period.

The purpose of the CFU quiz was to encourage students to actively participate in class as well as to determine whether students were understanding the material. The difficulty of the quizzes was targeted to the same level as the first several tasks for the team-based activities, so that any team that completed at least two tasks (and understood what they were doing) would be prepared for the CFU. At the discretion of the instructor, the CFUs would either be completed individually or as a team, and this could change from class period to class period. This was done to ensure individual accountability for the material and so that one strong team member would not carry a team over the course of the semester.

During class, the in-person students sat at individual tables with the rest of their teammates to facility teamwork on the activities and CFUs. The students attending class remotely were broken out into Zoom breakout rooms during the working portion of the class. Peer teaching assistants, graduate teaching assistants, and the instructor would then circulate through the classroom as well as the online breakout rooms, answering questions and providing guidance on the activities.

Instructors also utilized a variety of additional tools to facilitate delivery of the material as well as team collaborations. Several instructors utilized Discord to aid team collaborations both in-class and out-of-class. Channels were set up for each team that allowed them to engage in video or written discussions and share materials related to assignments or projects. Depending on instructor preference, Zoom, Discord, MS Teams, and WebEx were utilized to hold office hours and meet one-on-one with students.

Faculty Engagement Strategies Survey (FESS)

In order to pool together all the opportunities and engagement strategies that were employed by each of the faculty involved in the delivery of this course, a Qualtrics survey was developed and administered anonymously and internally in the Fall of 2020. The survey comprised of three open prompts (engagement strategies used in fully remote, hybrid in-person, hybrid remote) in addition to demographic questions like years of teaching, number of sections taught, gender, race, etc. Each of the prompts enabled faculty to enter four strategies that they had employed in their respective hybrid or fully remote classroom. An example prompt is,

The four primary strategies (not part of the course structure) that I use in my remote classes (all remote) to promote student engagement are:

Additionally, the survey included three open-ended questions pertaining to evaluation of the success of or effectiveness of these strategies, feedback they received from students about these strategies, and finally if there were strategies that they would use in the future that they have not already used. Faculty were sent two written reminders and one in-person reminder during the weekly faculty meeting. This paper will only present the different ways faculty assessed engagement in addition to the various engagement strategies.

Analysis: The primary author reviewed the responses to identify unique and similar responses in terms of strategies and collected all the unique responses of assessments used, including faculty provided student responses to their strategies. There were no codes generated as textual data was not exhaustive and unstructured but instead was primarily a list of the technologies and teaching styles used that faculty identified as an engagement strategy. The qualitative data was reviewed by the primary researcher in two iterations as a check for consistency. Following this the items were written for the Student Engagement Survey. These were then reviewed by the second author, who is also one of the faculty, to check for appropriateness in terms of comprehension and context. As the FESS was an open-ended questionnaire consisting of textual responses, no validation analysis was performed on this survey. A descriptive analysis of the demographic data was performed in Excel.

Student Engagement Survey (SES)

The student engagement survey was also internally developed during the Fall of 2020 and it included the responses that were pooled together from the FESS survey. The developed survey had two unique sections. The first section of the survey, called the engagement strategies, comprised of all the strategies that were employed by the faculty in the class and had 36 items, including two open-ended questions. In order to evaluate students' level of engagement these items utilized a 4-point Likert scale that ranged from *not at all engaging* (1) to *highly engaging* (4). The scaling was adapted from Seymour et al, Student Assessment of Learning Gains Survey [18]. There was also a *not applicable* category for students to select if a strategy was not employed in their specific learning environment. The items for this section of the SES involved instructor and TA specific activities, technologies employed (e.g. Zoom/WebEx chat), discussions, and questioning, to name a few. The second section of this survey had student specific activities that were rooted within the chosen theoretical framework and the conceptualization of engagement (affective, behavioral and cognitive) adapted from the motivation and engagement survey [19] and the learning propensity survey [20]. This section had 21-items with the student-centered engagement items on a 4-point Likert agreement scale ranging from *I do not agree* (1) to *strongly agree* (4). *Not applicable* was added for the students to choose if the items were not relevant to the learning environment. The learning propensity items were on a 6-point Likert scale ranging from *never* (1) to *everyday* (6). In addition to demographic questions, the survey also asked open-ended questions to gain more deeper understanding of their endorsement, including challenges they faced, technologies they would like retained once social distancing was no longer required, and strategies that both faculty and students can undertake to help stay engaged in the learning environments. We will only present the challenges in this paper. This survey was also administered anonymously via Qualtrics.

Prior to administering the SES to students, researchers modified the items for comprehension and readability and then sent the survey via Qualtrics to all the faculty teaching the course for their feedback and opinion using a simple yet structured Delphi method [21]. As part of this process, faculty were asked if they agreed with each of the items going on the student engagement survey. They could endorse an agreement level on a 4-point Likert scale ranging from *strongly disagree*

(1) to *strongly agree* (4). Items with a low rating average were deleted and based on the rating some items were re-written. Two open-ended questions were added to gather what strategies they would continue when social distancing is not required and what challenges they faced in the hybrid and fully remote LEs. While it was planned to send at least two iterations of the survey to the faculty, based on the feedback from the first iteration, the wording of the items was modified further and was created in Qualtrics for administration the last week in November of 2020. The survey was made available to students for one week.

Analysis: The data from the Delphi method was analyzed descriptively in Excel and the textual data was analyzed to identify challenges and strategies that would be retained using basic manual content analysis. The quantitative part of the SES was analyzed descriptively using Excel and SPSS. The first section of the survey, which included all the strategies specifically used by the faculty teaching the course, was tested for dimensionality using an exploratory method, namely the principal component analysis in SPSS, as these were just strategies pooled together there was not a hypothesized model to test against [22]. However, as the second part of this survey, the student specific strategies and propensity was developed from the engagement theories and adapted from existing instruments as previously discussed, the analysis was carried out in Mplus8 to confirm the factor structure. Following this the internal-consistency was tested by computing the Cronbach alpha values for the both sections of the survey independently and also for the sub-scales.

The open-ended responses were analyzed in a two-step process by first doing a text mining in R and NVivo to look at the frequently occurring words and sentiments. The auto coding feature in NVivo was used in addition to manual coding as a measure to check the primary researchers coding with the software for consistency. After these, the text within these were thematically coded to encapsulate the experiences of the students in terms of engagement in their learning environments. Unlike interview data, which is extensive text data, this data only had short sentences that respondents had typed as part of their survey. Each of these sentences were read and as the primary researcher was reading it, short memos were created, and codes were generated using a combination of affective, emotions, and in vivo coding [23,24]. This process continued iteratively until saturation was reached.

Results:

This section will first present the results of the FESS followed by the SES.

FESS:

This survey was administered the end of October to 13 faculty via Qualtrics and received a response rate of 77% (10). Of the respondents, 38% (3) identified as women and 62% identified as men (5) and 88% (7) identified as White/Caucasian. The faculty who responded to the survey had 3-5 years (3), more than 5 years (3), and 10 or more years (4) of undergraduate engineering teaching experience and have taught 1 to 8 online classes. 90% (9) of them taught in the hybrid format. The one faculty that taught a fully remote class listed they met with students via Zoom, Discord, Teams and WebEx and Discord was available to students to connect in teams any time. Another engagement strategy this instructor listed was to have optional sessions like office hours on Friday for discussion and for Q&A. However, they did not continue this due to lack of interest. Table 1 below shows a summary of the engagement strategies that faculty listed as being used in the Hybrid in-person and Hybrid remote learning environments. There was no difference in the strategies listed by faculty based on the gender, years of teaching, and number of online classes taught.

TABLE 1 List of Primary Engagement Strategies in ENED 1100 Hybrid LEs

Strategies	In-Person	Remote
Discussions	• Talking to student while they work on activities • Whole class • Conversations with each student and teams	Same but in the virtual space
Questioning	• TAs • Instructor • Walk around the room answering questions • Asking individual students questions	Answering questioning via chats both TAs and instructors
Monitoring/Observations	• Checking on student progress • Walk around the room see if students need help • TAs and instructors' observations to see if on-task	• Pop in/out of chat/breakout rooms both TAs and instructors to check progress
Online Tools	• Zoom • WebEx • OneDrive • Canvas • Teams	Same
Review	• Quiz • HW/Assignments • Review canvas course page and technology used	Same
Others	• Polling • Reminders about video lectures • Tracking time to ensure they are getting through activities • Whole class problem solving • Draw connections to future careers	In addition to what was listed for in-person, • keeping the camera ON while presenting content and while working through examples. • Ensure all members of the team are attending class (either in-person or remote)

Faculty informally assessed engagement by way of student enthusiasm, feedback on mid-semester surveys, through discussions, and type and frequency of response to the question(s). Formally it was assessed via performance on assignments and through student work. They also further reported that students have reported that they are appreciative of the methods used, especially spot questions and anonymous polls, and are pleased that faculty care for their progress. Student's responded most to instructor-led examples and problem solving and also when humor was injected into class.

SES:

This survey was administered by the department at the end of November (before Thanksgiving) to all students in the course. The analysis sample post-cleaning had 1253 respondents with a 92% response rate. The average age in years of the respondents was 19 and 19% (232) were in fully remote LE and 81% (1021) were in hybrid LE. 19% (233) identified as women, 80% (1008) as men and 1% (12) other. 80% (999) identified as White/Caucasian, 10% (123) Asian or Asian American, 3% (38) as Black or African American, 4% (55) multiracial, 3% (38) other. 95% (1188) were citizens or residents and 5% (65) were international students. The sample was representative in terms of gender and residency. During the Fall 2020 semester, 60% (757) of the students were in an on-campus residence hall or dormitory, 30% (373) were at home with parent(s) or guardian(s), and 10% (123) were in other off-campus living situations.

Survey Validation

SES ENED 1100 Faculty Employed Strategies: A principal component analysis with oblique rotation was carried out for the engagement strategies section of the survey that were specifically initiated by faculty on a sample of 407 after eliminating the *not applicable* responses. The sample size above 200 is considered a good target for this analysis [22]. The principal component analysis with oblique rotation yielded a 5-factor structure using an eigenvalue cut-off of 1.0 and scree plot with the KMO (Kaiser-Meyer-Olkin) test of .95, which shows there is no multicollinearity, and Bartlett's test of Sphericity produced a highly significant $\chi 2$ ($p < .001$), showing a good correlation and a sample size that exceeded the recommended 2:1 participant-item ratio [25]. This explained more than 65% of the data. The engagement strategies were grouped as discussions/questioning, reviews, Instructor and TA initiated class activities, technologies, and other class specific instruction methods (Table 2). After this analysis, the Cronbach alpha was computed as a measure of the reliability for all of the strategies and then for the specific factors (sub-scales). The factor loadings (absolute values) for the items were > .4 per the common standard and the overall reliability was .96.

SES Student Specific Strategies and Learning Propensity: For the second section of the survey, as the student specific strategies and learning propensity section of the survey was based on a hypothesized four-factor model, a CFA was performed. The assessment of the four-factor model was based on if it fit the data better than other models and if this provided a good absolute fit. Table 3 provides the comparison of the models in terms of the fit indices. As shown, the four-factor oblique model converged better in the relative sense based on the CFI, TLI, and SRMR values. As the data was ordinal a WLSMV estimator was used. The four-factor model provides a better fit to the data than a model hypothesizing for four orthogonal factors, $\chi^2_{difference}$ (6) = 1453.19, p<.0001, or one factor, $\chi^2_{difference}$ (6) = 1201.83, p<.0001. While the four-factor model is a better fit than other models, the model itself is not a great fit based on the standard values for the fit indices (CFI, TLI, RMSEA, and SRMR) [26,27]. The reason for this is that in a CFA, while items are forced to load onto one factor alone without accounting for moderate cross-loading of items onto other factors, this results in a model that does not fit the data well. To compensate for this, another fairly new model was run called the exploratory structural equation model (ESEM), which is a combination of exploratory and confirmatory analysis and does not constrain the items to a single factor and helps explore the underlying factor structure [26,28]. Figure 2 shows the model as conceptualized theoretically.

TABLE 2 Factor Loadings and Cronbach Alpha Values for Faculty Employed Strategies

Items	1	2	3	4	5	α
Discussions and Questioning						
Discussions with TAs	.49					.83
Discussions with Instructors	.71					
One-on-one questioning: TAs within teams (Team asking the TA questions and TAs asking the team questions)	.66					
One-on-one questioning: Instructor within teams (Team asking the Instructor questions and Instructor asking the team questions)	.78					
One-on-one questioning: Instructor and the whole class (As a class, students asking the Instructor questions and Instructor asking the class questions)	.69					
Review						
Review of RATs		.67				.87
Review of homework assignments		.69				
Review of material from pre-class videos		.70				
Review of content learned or what will be covered each class		.69				
Review of Canvas course website		.51				
Review of technology used in the course		.57				
Instructor and TA initiated class activities						
Instructor walking around the room (for hybrid in-person setting)			.48			.89
TAs walking around the room (for hybrid in-person setting)			.75			
Instructor dropping in and out of breakout rooms			.60			
TAs dropping in and out of breakout rooms			.79			
Instructors watching Zoom/WebEx/Teams/Discord Chat and responding promptly			.44			
TAs watching Zoom/WebEx/Teams/Discord Chat and responding promptly			.60			

Technologies						
Zoom breakout rooms				.60		.91
Zoom chat				.72		
WebEx breakout rooms				.80		
WebEx chat				.84		
Teams in general				.59		
Discord				.69		
OneDrive				.67		
Google Docs				.68		
Others						
Pacing of the class					.51	.87
Instructor wait time after asking a question in class					.54	
Instructor keeping the Video ON while presenting content/working on examples					.74	
Students having their video ON during breakout sessions					.75	
Polls/polling					.63	
Instructor ensuring all members of the team present for Zoom meeting					.71	
Instructors drawing connections between present content to future work in respective engineering fields					.68	

TABLE 3 Fit Indices for the Models

Model	χ^2	***df***	***CFI***	***TLI***	***RMSEA***	***SRMR***
4 factor (orthogonal)	7801.46	189	.54	.49	.21	.24
One factor	5392.33	189	.69	.65	.17	.11
4 factor (Oblique)	2208.09	183	.9	.9	.11	.07
ESEM	709.03	132	.97	.95	.06	.03

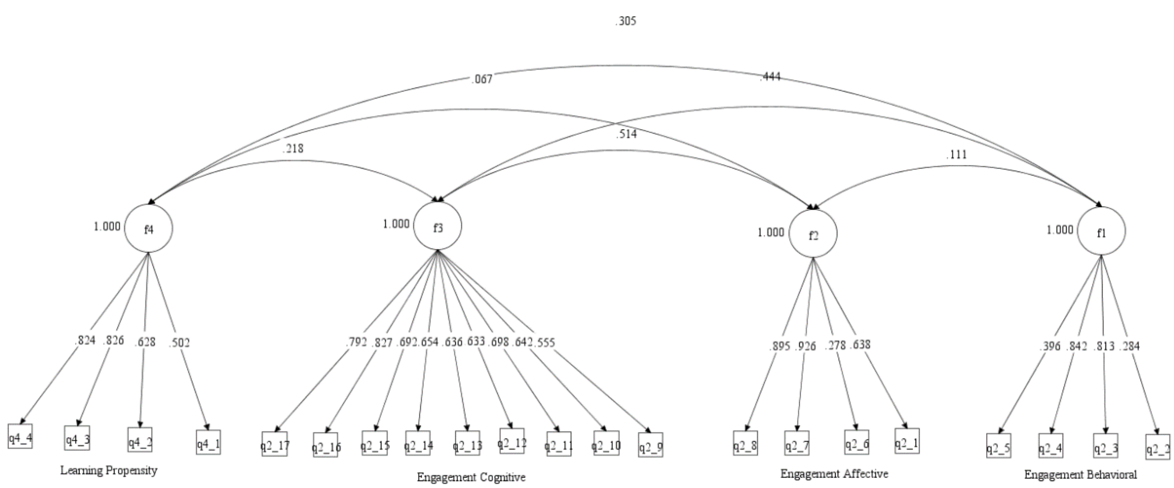

FIGURE 2: ESEM Latent Model for Student Centered Engagement and Learning Propensity

For presentability, Figure 2 only shows the standardized estimates of the stronger loadings. The table in the appendix shows the standardized loadings and the cross loadings for the ESEM model along with the item variance (R^2 explained by the hypothesized model) and also a table of the interfactor correlations (disattenuated). The ESEM model was a better fitting model, $\chi^2_{difference}$ (51) = 1142.28, p<.0001, providing an absolute fit to the data, χ^2 (132) = 709.03, p <.0001, CFI = .97, TLI = .95, RMSEA = .06, SRMR = .03. As seen in the appendix, all items load significantly (p <.01) and strongly on the hypothesized factors. Items at a cutoff loading of .3-.4 (*Feel excited in the hybrid in-person class; Pay attention to all the course announcements from my instructors and TAs; Use most of the opportunities provided to help succeed in this course*) had weaker cross-loadings on the other factors. The overall reliability of this section of the survey was .89 and the sub-scale reliabilities are also shown in the appendix. It was decided to re-word the item on excitement to *feel excited learning in the hybrid in-person LE* and re-word the attention item to *pay attention to all activities in my learning environment.* The item on opportunities was also retained as it had a very weak cross-loading on other factors.

The next section will briefly report on the student's evaluation of the faculty engagement strategies, student levels of agreement on the various domains of engagement as a result of these strategies and their learning propensity. Only strategies that received the highest average for fully remote and hybrid LEs will be reported. The results for the secondary questions are summarized in Table 4.

TABLE 4 Students Evaluation of Engagement Strategies

Strategies	Student Endorsement (Both LEs)	Example
Discussion and questioning	Instructor discussion s and questioning (3.0 $\geq M \leq$ 3.3; 0.82 $\geq SD \leq$ 0.92)	*The questioning sessions were really helpful. We were allowed to ask questions both in Zoom and discord.* (Fully remote, Man, 19, international student)
Technologies	Discord, teams, and Zoom breakouts (3.2 $\geq M \leq$ 3.4; 0.85 $\geq SD \leq$ 0.93)	*Discord was the most useful, especially when TAs went in. I wish it was like this for all my classes.* (Hybrid, Man, 18, non-international student)
Reviews and other instructor/ TA class activities	• Over 50% endorsed being engaged instructor and TA initiated activities. • 44% endorsed instructors watching the different online environments and responding to chats promptly as highly engaging. • Over 50% endorsed instructors drawing connections between present content to future work in respective engineering fields as the most highly engaging.	
Learning propensity	• Endorsed higher propensity for paying attention, working independently, and keep working on a task until it is finished. Endorsement average > 5.0 (3 or 4 times a week) but less than 6.0 (everyday). • Women significantly endorsed higher propensity for paying more attention than men.	

For the behavioral domain of engagement, completing all class assignments and projects on time received the highest averages for agreement both in the fully remote and hybrid LEs ($3.2 \geq M \leq 3.6$; $0.64 \geq SD \leq 0.94$). For the affective domain of engagement, fully remote got the least average ($M = 2.10$; $SD = 1.05$) for the environment helping them staying connected with classmates and contributing to socialization during the pandemic with women agreeing the least ($M = 1.90$; $SD = 0.9$). For the cognitive domain of engagement, fully remote had higher agreement averages from students for researching additional information to improve their learning, reviewing content they don't understand, asking questions and sharing ideas during whole class discussions ($2.8 \geq M \leq 3.2$; $0.78 \geq SD \leq 1.04$) compared to hybrid LEs.

65% (814) of the total survey respondents reported Hybrid in-person is the most engaging LE and only 9% (116) found fully remote to be engaging. When asked for the reasons for why in-person was the most engaging, the dominating theme was easier communication, face-to-face interaction, and being more focused. For fully remote, students said that this was their only option available in the pandemic, and safety was important. Finally, students reported that time zone challenges, technical issues, distractions (family, social media, lack of positive peer pressure), and a lack of hands-on learning with student-instructor interactions were the primary challenges that hindered their engagement in their LEs.

Discussion and Conclusion:

The purpose of this research study at the University of Cincinnati was to evaluate the engagement strategies that faculty used in a first-year engineering classroom in both the hybrid and fully remote LEs. This exploratory research study accomplished this by developing two surveys: one for the faculty to pool together all the engagement strategies and the other for the students to evaluate these strategies by rating their level of engagement, their level of agreement on the student specific tasks that theory suggests as measuring the three domains of engagement, and finally their learning propensity. In terms of the psychometric properties of the SES survey, both sections of this survey had acceptable reliability overall for the specific scales and was proven to be a multidimensional instrument for the current sample consistent with the original surveys [19] [20]. While we had more students in a hybrid LE in comparison to the fully remote LE, their responses were similar. A common theme that kept recurring for both LEs was that students clearly indicated that in-person is their preferred learning in terms of keeping them engaged, focused, and providing for better communication. Concurrent with faculty methods of assessing engagement, students also reported that instructor led discussions and questioning were comparatively more engaging to them. Distractions and time-zone challenges that students faced that hindered their engagement can be avoided in an in-person setting. Research suggests that attention is an important consideration in designing virtual classrooms [29] and for this sample, students indicated a higher propensity to pay attention with women endorsing this higher than men. They were happy for most part with the strategies that were incorporated by the faculty finding Discord, Teams, and Zoom breakout rooms to be engaging for both learning environments.

For the current sample, this survey was administered along with another departmental survey. In the future, it would be better to administer this a week prior to the departmental survey to avoid survey fatigue and administer different versions to both international and non-international students separately. Students during their conversations with faculty had shared that they prefer in-person class and this anecdotal evidence was supported by the data that was collected through this study. Not applicable was a category that was not analyzed as we did not have many students check that. However, the students who checked not applicable might have checked it as the particular faculty in their section might not have used that particular strategy, or they might have checked it in error or in a rush to move onto the next question and complete the survey. For future administrations of this survey, this option will be removed. This particular study assessed propensity to learn based on student ratings of their self-regulation but it would be interesting to also investigate this based on faculty ratings of the student's self-regulation and propensity to learn as a result [20]. Additionally, given that students recommended they have more opportunities to be part of the community and to connect, it may be beneficial to also investigate in the future not only the opportunities presented in general as was done for this study but also specifically pool together faculty-initiated integrated learning activities that would also promote connection and community as in the current LEs that is governed by the pandemic, social process unfolds through both human and non-human agencies [30].

While this study has accomplished what it set out to explore, with institutes of higher education planning to return to campus for 100% in-person learning, it would be valuable to administer this survey again to evaluate strategies that were introduced with the hybrid and fully remote settings in the context of in-person learning. This would allow the evaluation of their efficiency in terms of engaging students and also in terms of engagement in the context of flexibility to learning. For example, when asked what students would prefer to retain in post-pandemic times, a frequent response was the retention of recorded lectures, as it serves as a resource for future review of content. This would require engineering departments to install technologies like Echo360 (or similar platforms) for live lecture capture with closed captioning. Another area to explore to strengthen the effectiveness of the engagement strategies would be to link levels and types of engagements with the performance in the course(s). The pandemic forced more students to be exposed to online technologies and rely on online videos more than in the past. Upper level students' performance in terms of using these technologies in the pandemic era (data collected in Fall of 2020) and the post-pandemic (Fall 2021 if we return to in-person LE) era could also be evaluated in the context of learning to make informed decisions regarding what technologies needs to be pursued and invested into that would help diverse groups of learners.

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Appendix-ESEM Factor Loadings, Item Variance Explained, and Factor Correlations

Items	1	2	3	4	R^2	α
Engagement Behavioral						
I pay attention to all the course announcements from my instructor and TAs	**.30****	.26**	.29**	.12**	.46**	.75
I complete all my class assignments on time	**.81****	.18*	-.04*	.04	.72**	
I complete all my projects on time	**.84****	-.03	.09	-.00	.78**	
I use most of the opportunities that are provided for me to help me succeed in this course	**.40****	.21**	.37**	-.00	.57**	
Engagement Affective						
Hybrid or fully remote learning environments have helped me stay connected with my classmates and contributed to my socialization during the pandemic	.04	**.64****	.09	-.02	.48**	.77
I feel excited to learn in the Hybrid in-person class	.14*	**.30****	.33**	.00	.35**	
I feel excited to learn in the Hybrid remote class	.04	**.93****	.00	-.03	.86**	
I feel excited to learn in the fully remote class	-.07*	**.89****	.02	-.01	.81**	
Engagement Cognitive						
I am interested in most of the course activities	.07	.23**	**.56****	.09*	.58**	.88
I like to research additional information to improve my learning	-.06	0.19**	**.64****	.07*	.57**	
I discuss content I don't understand with my peers	.23**	-.22**	**.70****	-.02	.55**	
I go back and review content that I don't understand	.27**	-.03	**.63****	.03	.62**	
I ask questions of my instructor and/or TAs related to course content I don't understand	.14*	.11*	**.64****	-.06	.56**	
During my team discussions, I ask questions or share ideas or make suggestions	.26**	-.12*	**.65****	-.03	.56**	
During the whole class discussions, I ask questions or share ideas or make suggestions	-.06	.20**	**.69****	-.10*	.61**	
I like to be part of the engineering learning community at UC and participate in engineering events	-.08*	-.00	**.83****	.02	.64**	

Items	1	2	3	4	R^2	α
I like to share and/or discuss my learning with people outside of my class	-.01	.01	**.79****	.06*	.65**	
Learning Propensity						
How often are you eager to learn new content?	.09*	.07	.3**	**.50****	.45**	.74
How often have you paid attention in your respective learning environment?	.07	.01	.15*	**.63****	.50**	
How often have you worked independently on tasks?	.05	.03	.09*	**.83****	.68**	
How often have you kept working on a task until it was finished?	.01	.02	.005	**.82****	.68**	

Note. Hypothesized loadings in bold; *p<.05; **p<.0001

Factors	1	2	3	4
Engagement Behavioral	1			
Engagement Affective	.11*	1		
Engagement Cognitive	.44**	.51**	1	
Learning Propensity	.31**	.07	.23**	1

Note. *p<.05; **p<.0001