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BOARD #115: Engagement in Virtual Learning Environments with a Pursuit of In-Person Collaborations

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Engagement in Virtual Learning Environments with a Pursuit of In-Person Collaborations

Abstract

As virtual learning continues to evolve following the COVID-19 pandemic, understanding how students collaborate in these environments has become increasingly critical for educators. Research underscores a significant link between peer interactions and collaborative learning outcomes, emphasizing the need for effective virtual collaboration strategies in engineering education. This study examines student learning patterns, collaborative processes, and their impact on learning outcomes in virtual environments through a quantitative survey of 290 students from the college of engineering at [XXX] university in the United States. The survey measured perceptions of engagement and virtual collaboration, focusing on communication methods, interaction patterns, platform usage, and their influence on performance and collaborative effectiveness. The findings revealed that most participants were satisfied with the virtual teaching environment, but preferred face-to-face communications and collaborations with their peers with 6% of students preferring purely virtual communication. This emphasizes the importance of physical interactions and highlights the need to improve virtual collaboration. Also, students generally reported feeling comfortable, committed, and supported by their peers, fostering a strong sense of community and shared responsibility. However, some students felt like outsiders, which affected their sense of belonging. This research provides valuable insights into how virtual collaboration shapes student engagement and offers guidance for designing effective online engineering education programs.

Introduction

Virtual learning environments offer flexibility in creating communication channels and shaping how engineering students would interact, engage, network, and collaborate with their peers, while removing the physical interactions inherent in traditional systems [1, 2]. The evolving nature of education due to digital technologies and rapid acceptance of online education has made virtual learning environments a vital component of modern pedagogy, necessitating and increasing the need to understand virtual collaboration dynamics, its effects on student engagement, and sense of belongingness to facilitate effective teaching-learning experiences [3]. This problem is important for construction engineering and management (CEM) students especially because the architecture, engineering, and construction (AEC) industry is shifting toward a higher level in virtual design and construction (VDC).

Existing literature emphasizes that active collaboration is greatly influenced by the quality of interactions amongst students [4, 5]. With this meaningful engagement, students described their communications as productive and valuable, ultimately contributing towards improved academic outcomes [6, 7]. Similarly, virtual learning has developed a relationship between communication media, collaborative platforms, and social interactions that not only influences academic performances but also creates a sense of community and shared responsibility among the students

[8, 9]. Research conducted among graduate students revealed a strong correlation between collaboration and a sense of belonging, indicating that enhancing collaborative efforts directly improves belonging, reinforcing the need for tailored strategies for different student cohorts [10]. However, these environments present opportunities and challenges; therefore, identifying and analyzing the communication and collaboration patterns in the classroom can contribute immensely to fostering meaningful learning experiences and improved collaborative efforts[6, 7, 10].

The objective of this research is to enhance an understanding of virtual collaboration, student engagement, sense of belonging, and interactions within virtual environments, and their impact on academic and social outcomes. This study seeks to identify collaboration patterns, assess the effectiveness of collaborative processes, and evaluate their influence on engagement and belonging. The aim is to provide insights for designing and implementing educational programs, offering practical guidance to educators and administrators in fostering student engagement and improving learning outcomes in virtual settings.

Background

Virtual Collaboration and Student Engagement

Engagement in virtual learning environments is influenced by an instructor's capability to establish interaction and active participation among students [11, 12]. One way of encouraging participation is through structured collaborative activities, which enhance critical thinking, problem-solving skills, and cognitive understanding [13, 14]. For example, research has shown that cooperative learning strategies, such as interdependent tasks, significantly increases engagement at both individual and group levels [15, 16]. However, these may not directly improve academic achievements; hence, the approach should be diversified by incorporating aspects of technology and social dynamics [17].

The use of virtual reality technology has emerged as a promising tool to enhance the sense of presence and engagement in online lectures, narrowing the gap between physical and virtual interactions, ultimately enhancing positive peer relationship [18, 19]. For example, technological tools, like StudentViz, has been instrumental in visualizing collaboration patterns that enable educators to tailor effective teaching strategies [20]. In summary, technology facilitates collaboration, positive collaboration helps active learning and active learning improves students' performance [18-20]. Despite these, challenges persist, including the absence of physical contact and the potential feelings of disconnection, isolation and alienation among students, which may or may not directly influence academic achievements [21-23].

Virtual Collaboration, Patterns of Collaboration and Sense of Belongingness

A sense of belonging is crucial for the success and well-being of students in virtual learning environments [24]. Small group discussions and team-building exercises help students feel socially accepted, significantly reducing aggressive behaviors, and encouraging positive peer relationships [25, 26]. However, diversity in the sphere of peer relationships (whether based on gender or socioeconomic status) does not necessarily contribute to a greater sense of belonging, which raises a question about how best to foster inclusivity in virtual spaces [18].

Collaboration patterns in virtual classrooms are important aspects to be considered when designing learning activities [27]. Cooperative learning can change the dynamics of peer relationships, reducing exclusivity and encouraging broader network [28, 29]. These strategies emphasizes the role of the educator in facilitating interactions, ensuring that discussions remain meaningful and authentic [30].

Additionally, computer-mediated communication has also been found to increase collaborative patterns in pair interactions, especially in language learning contexts [31]. Online teamwork studies conducted in programming courses show that increased peer communication promotes better learning outcomes, hence showcasing the potential of technology for supporting collaboration [32]. However, traditional discourse patterns often prevail in students' communicative choices even when collaborative activities are clearly introduced [33, 34]. Tools and methods such as project based learning (PBL) and the use of project charters in PBL environments provides a platform for structured coordination and facilitating increased collaboration in the educational settings [35]. It is therefore important to note that effective collaboration requires a balance between structured activities and spontaneous interaction, as over-structuring may impact its creativity and the engagement level.

Methodology

Research context and participants

This research was conducted in the College of Engineering at XXX University, located in the United States. XXX has predominantly in the past provided in-person undergraduate education. The institution adopted Desire2Learn (D2L) in 2012; it provided a platform where students could have access to lecture materials, upload course works, reference materials, and view their grades. The use of D2L platform provided ample online experience with the use of school and other resources for assignments. However, class attendance was a mandatory aspect of the undergraduate educational system, with most courses requiring physical presence for participation in lectures and coursework. As a result, students were expected to stay on campus or within its vicinity throughout the semester.

However, during the pandemic, students were asked to adopt online learning as they had to study from home. This necessitated online, hybrid, synchronous, and asynchronous classes since studying and working in a virtual environment was now an accepted method of teaching and learning. Most students had access to the internet and reported having computers and smartphones as an affordable means to online education. Although students had encountered some form of online education in the past using D2L, migrating completely online presented some pedagogical changes in active learning strategies and course design [36]. During this period, the students received specific training about using online learning platforms (virtual communities) for the start of emergent distance learning. The medium of communication was also upgraded from the very formal use of email to systems such as Piazza, which allowed students and instructors to communicate as a group. Students also adopted systems such as GroupMe, a platform to find colleagues, clubs, and other groups to ensure collaboration in both academic and social life as would be present on the school campus.

The course selected for this study was an intermediate programming course, open to all majors, especially those whose programs aligned with computational applications. With the growing integration of digital tools, AI, computational methods, and VDC in the AEC industry, computer

programming has become essential for Construction Engineering Management (CEM)students and professionals to develop basic skills in coding, AI and computing courses. These technical skills are necessary for automation, data-driven decision making and digital project management. This made CEM a strong fit for the evolving role of technological demands in modern construction practices as students were from different backgrounds. The class was divided into various sections with about 30 students in each section to accommodate the large size. Meanwhile, the medium of instruction was strictly virtual.

Ethical approval for research was obtained through the university's IRB system. The survey was distributed through a collaboration with the course instructor. It is important to note that the participants were instructed to complete the survey solely based on their experiences in this specific course. The students were asked to identify classmates they interacted/worked with during course assignments and projects; referred to as "*collaborators*" for the purpose of this study. Although the survey collected names and details of the students and respective collaborators, these identifiers were replaced with codes during the data analysis phase to ensure confidentiality and protection of participants.

A total of 301 students completed the survey; however, 11 were excluded due to wrong data provided; the students were required to write at least two classmates they interacted with in the class. However, some students typed information such as "no name", "none", etc. Therefore, such details were excluded from the data which was analyzed leaving 290 students for data analysis. Among these, 290 students listed two collaborators, 54 named a third collaborator, 16 identified a fourth collaborator, and 7 listed a fifth collaborator, resulting in a total of 657 recorded collaborators identified.

Instruments

The research employed a survey to explore student collaboration and measure their sense of belongingness. This survey was adopted based on previous engineering education research [37, 38] and its content was revised to contextualize the purpose of the study. It included 5 major sections; the medium of communication, pattern of communication (frequency and duration of communication with collaborators), the cognitive, emotional and social engagement with collaborators (effects and impacts), participants level of belonging and general demographics. Questions also included the mental processes of acquiring, understanding and applying relevant knowledge during the collaborative and participatory activities. It also included questions about students' perception of decision making, interactions and connections with colleagues, reactions towards classmates, and how they communicated to build and maintain positive relationships. These aspects collectively measured their sense of belongingness.

The survey was conducted using Qualtrics. It adopted a 5-point Likert scale, measuring from between 1- "*strongly disagree*" and 5- "*strong agree*", between 1 - "*not at all useful*" and 5 - "*extremely useful*". The patterns of communication during interaction were measured from an array of questions, ranging from a) the medium of communication with collaborators, i.e., "face to face", "email", "messenger", "audio/video chat"; b) the frequency, measured with "daily", "weekly" and "monthly"; and c) the duration for interactions was measured in time as "10minutes or less", "11-30 minutes", "31-minutes to 1 hour", and "> 1 hour". After completing the draft, 3 professors involved in undergraduate education research provided feedback on the survey and possible data collection process. A pilot study was conducted by 3 graduate students and 1 professor to give

feedback on the fluidity of the questionnaire and ease of answering the questions after participating. The recommended changes were affected and prepared for data collection.

Data Collection

A quantitative survey was used to collect the data. The priori sample size was calculated before conducting the survey to ensure that it had sufficient statistical power of 0.80 and effect size given at a significant level of $\alpha = 0.05$ to determine the expected relationships whether small, medium or large. The estimated sample size for the study was 254, with an anticipated effect of 0.30 and a desired statistical power level of 0.80. In this research, 301 students participated, therefore, the required sample size was obtained.

The mode of communication and collaboration was further grouped into three types: virtual, non-virtual, and mixed methods for further analysis. A descriptive analysis was conducted with the aim of exploring the dynamics of students' perceptions on belongingness and collaboration. Finally, factors influencing the effectiveness of collaboration based on the frequency of communication, ranging from daily to monthly were also analyzed. The details of the analysis and discussion are detailed in the subsequent section.

Results and Discussions

Descriptive Analysis

An analysis of the gender, year of college, race, ethnicity, and the locality of students was conducted. On gender, 79.3% of the students were men, 19.3% were women, while 1.4% did not disclose their gender. Concerning the distribution for the year of college, this class was open to undergraduate students in the college, there was therefore a mix in the students' current year of study, with Year 1 (4.1%), Year 2 (57.9%), Year 3 (29.3%), Year 4 (6.2%), and 2.4% in Year 5. This supports the study structure that certain courses are sometimes designed for a particular year of study, hence, over 50% of the participants were in Year 2. The [XXX] university is open to international scholars; from the survey, about 22% of the students reported to be international students, while about 78% were U.S. citizens and permanent residents, typically residents of Michigan and other states within the U.S. This may be due to the limited scholarship available to international students. Regarding race, 48.6% reported to be whites, 38.6% Asians, 5.9% African American while the remaining 5.9% reported to be of mixed racial identity, ranging between the races previously mentioned as well as Native American and Hawaiian.

Pattern of Collaboration

Research implies that adopting effective collaborative strategies has a significant impact on academic performance among university students [15]. Therefore, it was crucial to identify the patterns of communication and collaboration in classroom relationships among the survey participants, which may enhance interactions and improve learning experiences and outcomes. To assess the effectiveness of the various communication methods, the respondents were asked to indicate the medium of communication/collaboration with their peers. Among the 657 participants and collaborators, 57% preferred face-to-face interactions, 24% preferred messaging applications, 10% selected emails, while the least favored method was audio/video chat (9%), as illustrated in Figure 1.

The medium of communication was further categorized into virtual, non-virtual, and mixed (both) methods. As shown in Figure 2, 43% adopted the mixed medium, while 52% preferred a face-to-face interaction while only 6% of the participants preferred solely virtual communication, which was least expected considering that the class was taught online. The reason for such a result considering the medium of instruction was therefore attributed to the fact that many students lived on campus and attended other in-person classes with their classmates, which contributed to their preference for face-to-face communications. These findings highlights the impact of face-to-face (offline) communication in student interactions, which is essential in helping students become more efficient in class, compared to solely virtual means of communication, [33] even in online classes.

Additionally, to evaluate how often students interacted and collaborated on group assignments, the study measured the frequency of communication amongst participants. The results showed that, about 75% of the students interacted with collaborators on a weekly basis, 21% on daily basis, while only 4% interacted monthly. This pattern supports the structure of the course, which was held weekly, allowing students the opportunity to interact and discuss class assignments and projects, etc.
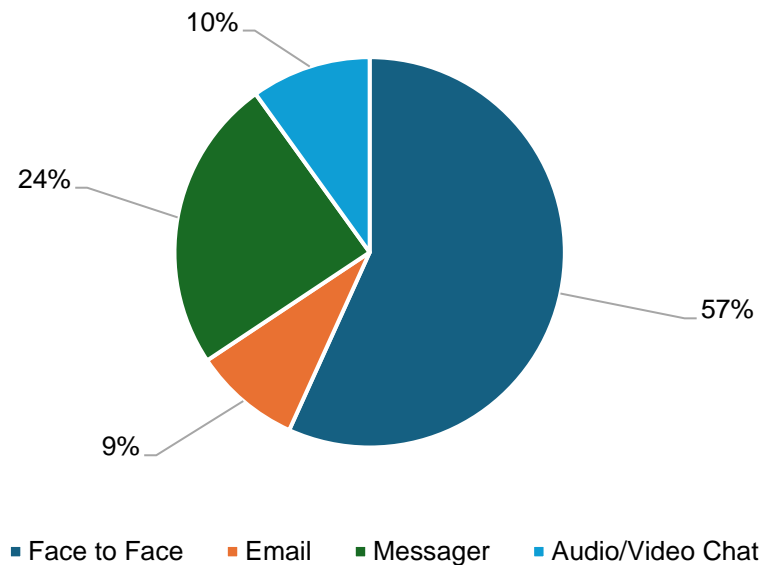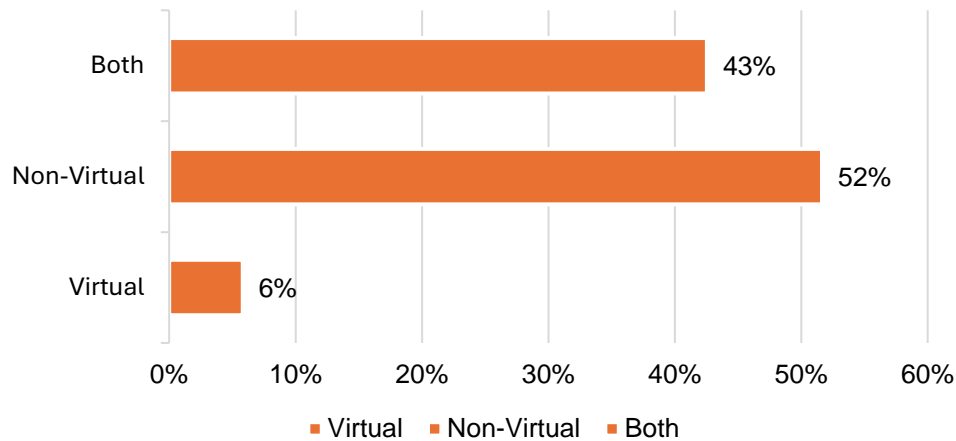

Figure 1. Medium of communication.

Figure 2. Style of collaboration.

Sense of belongingness

Another research objective was an evaluation of the students' sense of belonging. These were measured by assessing the responses of students on how comfortable they felt in the class, whether they felt a part of the class, supported by their classmates, felt like outsiders in class, and committed to other individuals in the class. Responses to these questions were ordered on a Likert scale varying from 1 to 5, with 5 as "extremely agree" and 1 as the lowest, "strongly disagreeing". Table 1 shows the frequencies in percentages of the variables while measuring the sense of belongingness. A graphic representation is presented in figures 3 and 4. It is observed from Figure 4 that approximately 27% of the students agreed that they did not feel a part of the class, 21% expressed a neutral stance, while 52% strongly opposed that they did not feel like outsiders in the class. This indicates a mixed distribution in their responses, differing from the more uniform results observed regarding "the feeling of comfortability/sense of comfort" in class. This suggests that because the class was online, although they were comfortable, a wide array of students felt like outsiders. These findings align with some previous research on the lack of physical interaction in virtual classes, often leaving students feeling isolated [39, 40].

Table 1. Sense of Belongingness

	Strongly disagree	Somewhat disagree	Neither agree nor disagree	Some what agree	Strongly agree	N	Mean	SD	Skewness	Kurtosis
Comfortable in class	2.4	5.5	12.4	37.2	42.4	290	4.12	0.984	-1.192	1.112
Part of the class	2.1	4.5	18.3	35.2	40	290	4.06	0.981	-0.961	0.524

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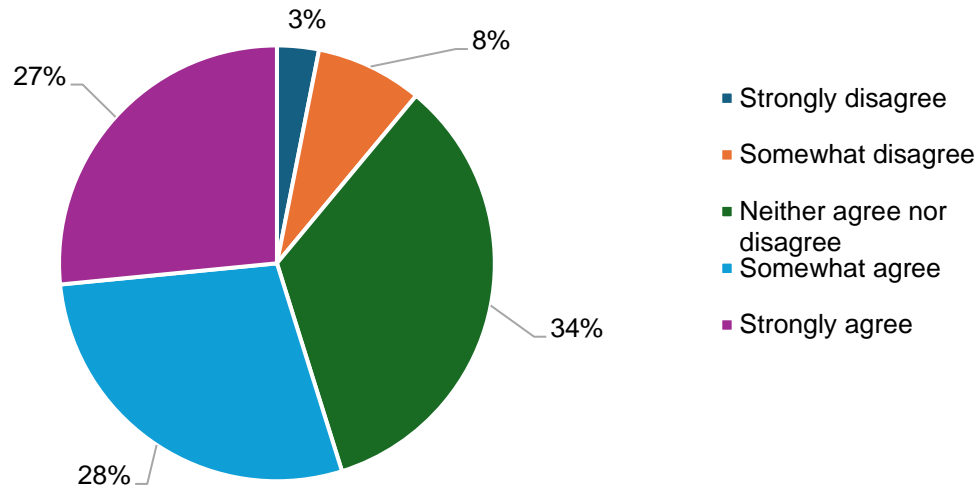|									
Supported by classmates	2.4	5.2	12.8	36.6	43.1	290	4.13	0.989	-1.185	1.059
Feel like an outsider	26.9	24.8	21	13.8	13.4	290	2.63	1.362	0.381	-1.05
Committed to classmates	3.1	7.9	34.1	28..3	26.6	290	3.67	1.044	-0.366	-0.406

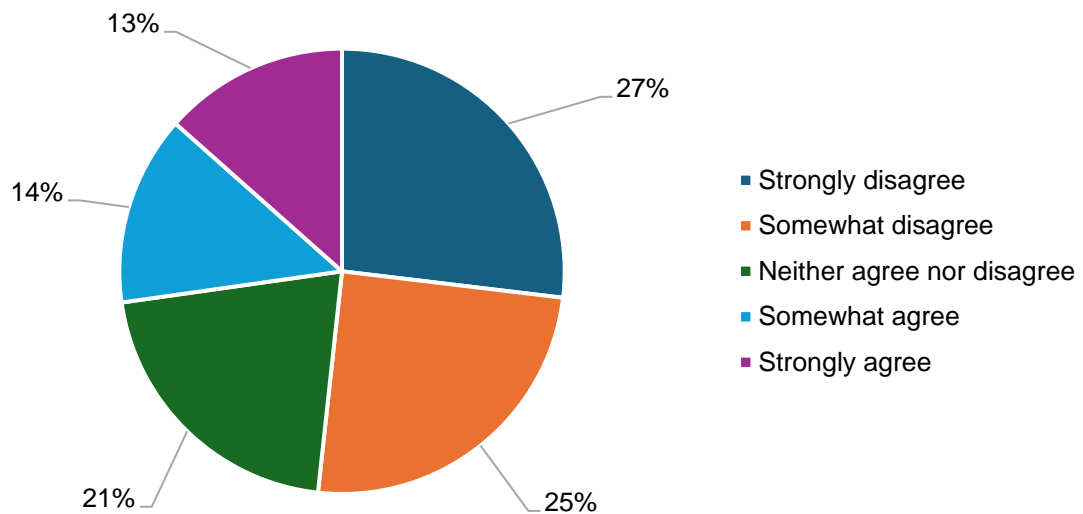**Figure 3. Level of commitment to individuals.**

Figure 4. Feeling belonged in the class.

Conclusion

This study investigates student engagement, collaborative impacts, and the sense of belonging in virtual learning environments, highlighting the exchange between virtual and in-person interactions. Data from a fully virtually taught course with 290 engineering students revealed that while virtual learning positively impacts academic outcomes, many students still expressed a strong preference for face-to-face interaction. Notably, only 6% of participants preferred fully virtual communication, highlighting the limitations of purely online collaboration with peers. The vast majority sought some form in-person interaction, with approximately 52% explicitly favoring face-to-face communication over virtual methods. This preference suggests that while virtual platforms enhance accessibility and academic outcomes, they do not fully replace the benefits of physical presence in fostering connection and effective collaboration. Moreover, weekly interactions, primarily aligned with class schedules, serving as a foundation for project discussions and peer engagement.

These findings emphasize the need for hybrid communication models that integrate the flexibility of virtual collaborations with the advantages of face-to-face engagements. Moreover, by recognizing students' inclination toward face-to-face engagement, educators can address the limitations of virtual learning by designing more effective learning environments that enhances students' sense of belongings and strengthen collaboration while improving the overall educational and learning experiences.

While our research aligns with existing literature highlighting how the lack of physical interaction in virtual classes can lead to student isolation, it has some limitations. One of these limitations is the absence of qualitative data which could provide a deeper understanding of the communication preferences of students and their relationships in the course structure.

Our future research direction will therefore incorporate interviews to explore students' reflections of their engagement with peers, sense of belonging, and the overall impact of virtual instruction on their collaboration and interactions in course works. Additionally, we will conduct a Social Network Analysis (SNA) to map the interaction patterns amongst individual students (nodes) and connections between students (ties) to identify the key influencers in the network while assessing the structural dynamics of engagement in online education. Similarly contributing to redesigning online courses to enhance meaningful collaboration amongst students without the limitations of isolation within the settings.

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