WIP: Impacts of COVID-19 on Diverse Engineering Students' Sense of Belonging

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Work-in-Progress: Impacts of COVID-19 on Diverse Engineering Students' Sense of Belonging

ABSTRACT

This work-in-progress paper studied the impact of COVID-19 ramifications on first-year engineering student sense of belonging at one research intensive institution in the southeast that hosts a strong engineering program. In response to COVID-19, the vast majority of collegiate institutions have shifted courses to remote, hybrid, or hyflex formats, which may result in diverse engineering students facing a "triple threat" to their sense of belonging in engineering courses since (a) STEM disciplines, (b) minoritized student identity, and (c) remote course formatting can all impede belonging. Diminished sense of belonging can, in turn, impact student retention and persistence, potentially intensifying imbalances that already exist in STEM fields. Therefore, this study sought to examine students' sense of belonging and factors that could contribute to increased belonging for diverse engineering students, especially in remote courses. Using a concurrent, mixed methods design in the Fall of 2020, the preliminary data in this manuscript highlight survey responses from 282 students (54% response rate), 7 focus groups with a total of 28 students, course observations, and student demographic data.

Key variables and concepts for the study include *sense of belonging* (measured with an existing 4-item scale for which the institution has historical engineering student responses as well as with qualitative interview questions), which is an empirically documented forecaster of student success, and the *Community of Inquiry* framework, broken into three constructs of *teaching, social and cognitive presence* designed to examine key elements of an online course (measured with an existing 34-item survey and qualitative interview questions). Preliminary findings suggest no statistically significant differences in sense of belonging, teaching presence, social presence or cognitive presence between students in marginalized and dominant identity groups (continued analysis of qualitative data will reveal nuances between groups not apparent in survey data); however, belonging was higher for students who attended class physically versus virtually most of the time. In addition, compared to a past (pre-pandemic) comparison, social presence was lower for all fall 2020 students. This project is supported via an NSF RAPID award created by the IUSE program in the Division of Undergraduate Education (Education and Human Resources Directorate), using funds from the Coronavirus Aid, Relief, and Economic Security (CARES) Act.

1. Introduction

In response to COVID-19, institutions have required students to pursue online, hybrid (with designated times to attend in-person and online), hyflex (with flexibility to attend in-person and/or online) and other remote course formats to contribute to student and societal health and safety. At the same time, such shifts in course formats raise potential concerns for students' learning and experiences in class, especially students' sense of belonging, or sense of "perceived social support on campus" and "connectedness" [1, p. 3] on campus given sense of belonging is a documented predictor of student success [2-3]. Scholars have documented that sense of belonging can be low for minoritized students across institutions of higher education [4-9] but

especially for racially minoritized students in STEM programs [10-11], where students of color are underrepresented [12]. In addition, sense of belonging can be more difficult to build in online classes [13], where attrition rates appear to be higher than in face-to-face courses [14-15].

Thus, in light of changes to course delivery in response to COVID-19, underrepresented engineering students (especially racially/ethnically underrepresented students, first generation students, women, and students from low income backgrounds) in remote classes have potentially faced exacerbated threats to their sense of belonging. The study, therefore, examined the differential experiences for first-year engineering students of diverse backgrounds in a hyflex, foundational engineering course in the fall of 2020. While the full study has additional research questions and will draw on additional data not yet been analyzed, in this paper we address: (1) What are the differences in sense of belonging for students in dominant versus marginalized identities (related to gender, race/ethnicity, first generation status, and low income) in a hyflex, first-year engineering course? (2) What are differences in students' reports of teaching, social, and cognitive presence compared to a comparison in-person group? (3) What are elements of hyflex course design and facilitation that contribute to students' sense of belonging?

2. Sense of Belonging in Light of Identity, Discipline, and Course Format

In this study, we focused upon the concept of sense of belonging because of its relationship to both student outcomes and positive student experience in postsecondary environments. While it is shown to contribute to student outcomes, such as persistence and performance [2-3, 16-17], sense of belonging also affords an understanding of a student's sense of connection within a course or postsecondary experience, which is especially important for underrepresented students who may feel marginalized [4]. Sense of belonging is "context-dependent" and has "heightened significance in settings" that are unfamiliar or isolating [1, p. 57]. An examination of belonging, therefore, seems imperative chiefly for underrepresented students in STEM fields who face identity, discipline, and course-format related barriers. Such barriers, in addition to the ramifications of COVID-19, diminish student's perceived sense of belonging within STEM courses.

2.1. Identity

Because of underrepresentation in engineering fields, identity poses an initial belonging barrier for some students, especially students of color and low income students within predominately White institutions (PWIs) [1, 18]. First generation students also tend to encounter a lower sense of belonging as they navigate unfamiliar college environments [1]. In addition, stereotype threat [19] is known to impact even high-performing, underrepresented students, such as women or Black students in STEM, who can underperform when assuming others' might hold negative stereotypical assumptions about their performance. Finally, students report pressures related to social class that make low-income [7, 20] and sometimes middle-class [8] students feel out of place on campus. Thus, a student's marginalized identity makes it more likely they will face a threat to sense of belonging.

2.2. Discipline

Scholarship has repeatedly shown that underrepresented students experience a low sense of belonging within STEM disciplines [10-11]. Strayhorn [1] found that belonging was especially important for students with minoritized racial/ethnic identities, and minoritized students leaving STEM majors often highlighted lack of belonging as a reason for departure. Both underrepresentation of students of color and women as well as stereotyping [11, 21] contribute to the threat that STEM disciplines pose for diverse students' sense of belonging. At the same time, scholarship has shown that fostering a sense of belonging in a course can provide gains for underrepresented students broadly [22], especially within STEM disciplines [17].

2.3. Course Format

Finally, sense of belonging can be more difficult to foster in online courses, where students may be less likely to persist [23] and where content delivery can overtake connection and interactive learning [13]. Scholarship has shown the importance of a perception of a positive learning community to students' engagement in online courses [23] and that collaboration is linked to student success in online environments [24]. Repeatedly, interactive course design, especially interaction among students [25], is cited as an important element for fostering success in online classrooms [24]. Thus, shifts to remote education because of COVID-19 have resulted in a third potential threat to a students' sense of belonging.

In summary, evidence suggests that underrepresented students, especially in STEM disciplines, face greater challenges to sense of belonging. An additional hurdle of remote learning in light of COVID-19 may further create inequities for students and their sense of connection to the course and the discipline, which could hinder performance and retention.

3. Conceptual Frameworks and Variables

Sense of belonging, as defined by Strayhorn [1], served as a first variable and conceptual framework for the study. Belonging was operationalized through both qualitative questions and an existing four-item scale [17, 22], for which the institution has historical data for engineering students. Furthermore, the Community of Inquiry (CoI) framework operationalized three key elements of an online course environment: cognitive, social, and teaching presence [26]. Cognitive presence is associated with critical thinking and attention to course material. Social presence is the existence of a shared community of learners, fostered through social interactions and presence of peers. Finally, teaching presence is the design and facilitation of learning, often contributed by an instructor of the course. CoI was measured with qualitative questions in addition to an existing survey instrument consisting of 34 five-point Likert scale items, structured into 3 factors [27]. The CoI framework helped provide insight into students' potential differential experiences of specific elements of the course under study as well as the ways in which each element may influence sense of belonging for diverse groups. Together, sense of belonging and the three CoI components provide the four main constructs of interest for the study.

Constructs of student identity were based on data collected by the institution. Race/ethnicity categories students could select included non-resident alien, black, American Indian/Alaskan Native, Asian, Hispanic, white, race unknown, two or more race, or Native Hawaiian or other

pacific island; for this study we broadly compare white students and students of color. Sex/gender categories included a limited two options of male/female. Income level of students for this study was based on students' Pell eligibility.

4. Methods

We employed a multimodal, concurrent mixed methods (quantitative, qualitative) design with a fall 2020 cohort of students to allow us to examine both broad trends and in-depth experiences related to student sense of belonging. We used a convergent parallel study [28] whereby quantitative and qualitative data were independently collected, in turn analyzed and then jointly interpreted. Modalities of data collection included a written post-course survey (quantitative Likert items and qualitative open-ended items), course observations, and focus group interviews. Conclusive analysis is currently ongoing, and in this manuscript, we report preliminary findings.

4.1. Site and Participants

The site for the study was "Southeast University" (SU – a pseudonym), a predominately White, urban research institution in the south with a strong engineering curriculum. Participants included first-year engineering students taking an institutionally-required hyflex (student flexible choice of in-person or remote participation) foundational engineering course in fall 2020 (n=522). Researchers were not involved in actual course design/redesign. The lead instructor for the course has additionally participated in this project via assisting with qualitative data assessment. To ensure safe spacing, students had designated days when they could attend class in person, though students could opt to attend online at any time rather than in person.

4.2. Data Collection

Data included institutional demographic data for students, student survey responses, student focus groups, and course observations. Data were collected in the last few weeks of the course so that students' responses reflected a full-semester experience. For the written survey, the response rate was 54% (282/522). Missing data analysis pertaining to the four different demographic identities under study consideration show a higher proportion of women responders (with respect to overall class composition), no difference in response proportions amongst non-white responders, and a lower proportion of responders (compared to entire cohort) from both low-income and first-generation cohorts. In addition to the belonging and CoI variables described above, the survey also included questions concerning the nature of their course attendance (approximate proportion in-person vs. remote) and participation (synchronous with class time irrespective of virtual or in-person, or asynchronous by watching recorded class videos) because the fall 2020 course was in a hyflex format.

For observation of courses, a protocol was developed using Spradley's [29] nine dimensions of observation in relation to research questions to help authors consider students' sense of belonging and course elements that might relate to belonging. Given the hyflex environment, two authors simultaneously observed 3 different course sessions, one observer attending online and the second observer in person.

Finally, end-of-course semi-structured focus groups were conducted as "interaction among interviewees," such as comparison, contrast, and shared understandings about aspects of the course, in an effort to help provide insight into research questions [30]. Select students in the course were invited to attend one of 6 focus groups. Populations of interest were well-represented, though an additional focus group was added to ensure participation of first generation, low-income students. Overall, 28 students attended a total of 7 focus groups in the fall, with group sizes ranging from 2 to 7 students.

4.3. Data Analysis

For this work in progress, preliminary **quantitative** analyses included descriptive statistics and crosstabulations of each grouping variable with attendance and participation modalities. A chi-square test revealed if the proportional distribution patterns of attendance and participation were similar or different for subgroups of students. Mean group comparisons of aggregate scale factors for the four constructs of interest (sense of belonging plus the three community of inquiry subscores) were analyzed with independent samples t-tests and included Cohen's *d* effect size estimations when a difference was identified. We also compared students in our sample to a pre-pandemic comparison group using data reported by the developers of the Community of Inquiry scale [27], using one-sample t-test with Cohen's *d* effect size estimated. Future analyses will include regression analyses and historical comparison of COVID-19 students with prior students for which the institution has data.

Qualitative studies include focus group interviews, which were recorded and transcribed for coding. We also engaged in constant comparison and analysis [33] analysis of focus groups throughout team meetings, and reviewed field notes and observer memos from classroom observations for triangulation of data. Initial coding is ongoing, with an incident-by-incident descriptive coding process that includes both predefined codes grounded in research questions (e.g., elements of cognitive, teaching, and social presence) in addition to emerging codes. Collectively authors are creating a shared codebook from the data. Second-phase coding will entail focused coding, categorizing themes relevant to research questions [31].

5. Preliminary Results and Related Discussion

Table 1 reports the data capturing how the various groups of student participants, based on our four particular underrepresented groups of interest, reported attendance and participation modes for the course. A chi-square test examined if the proportional distribution of each identity group categories was statistically similar or different in terms of attendance and participation modes.

These results showed that in only two cases were the proportional rates of attendance and participation different across subgroups. The nonwhite students tended to virtually attend at a higher rate than did their white peers. The low income students also tended to virtually attend at a higher rate than did their non-low income peers. For gender and first-generation status, all subgroups were inclined to attend virtually versus in-person in statistically similar proportions. And for all four identity groups of interest, all subcategories of students tended to participate in similar proportions synchronously (reasonably high since in all cases >75% synchronous participation) versus asynchronously.

Table 1. Attendance & Participation by Demographic Groups

	Mostly In-Person Attendance	Mostly Virtual Attendance	Mostly Synchronous Participation	Mostly Asynchronous Participation
Female	52 (61%)	33 (39%)	73 (87%)	11 (13%)
Male	116 (59%)	80 (41%)	152 (78%)	44 (22%)
Non-white	31 (43%)	41 (57%)	57 (80%)	14 (20%)
	***			
White	137 (67%)	71 (33%)	168 (81%)	40 (19%)
First-gen	32 (52%)	29 (48%)	47 (77%)	14 (23%)
Non-first-gen	136 (62%)	85 (38%)	178 (81%)	42 (19%)
Low income	25 (42%)	35 (58%)	44 (75%)	15 (25%)
	***			
Non-low income	143 (65%)	78 (35%)	181 (82%)	40 (18%)

Note. Percentages are within-subgroup proportions who chose each modality. Thus for example, of the 72 non-white students who responded to the survey, 43% (31/72) reported mostly attending in-person, while 57% (41/72) of non-white students reported attending mostly virtually. The triple asterisk in the middle of this 2x2 subtable indicates that the proportional distribution of in-person versus virtual was statistically different (chi-square test) for the non-white versus white students and the low-income versus non low-income.

***p<.001 in chi-square test of proportional distribution within 2x2 subtables.

5.1 Response comparison across groups

Although fully-realized analysis of the quantitative survey data is ongoing, some preliminary findings are available for dissemination. The main effect group comparisons for all four primary outcome constructs are shown in Table 2.

Table 2. Main Effects Group Comparisons on Outcomes

	Outcomes Mean(Standard Deviation)			
Category	**Belonging** (scale=1-5)	**Teaching Presence** (scale=0-4)	**Social Presence** (scale=0-4)	**Cognitive Presence** (scale=0-4)
Gender	F=3.59(1.00)	F=3.17 (0.53)	F=2.48 (0.58)	F=2.92 (0.44)
F=female, n=85	M=3.80(0.96)	M=3.04 (0.59).	M=2.51 (0.65)	M=2.81 (0.57)
M=male, n=196	NS	NS	NS	NS
Race	N=3.61(1.08)	N=3.06 (0.53)	N=2.56 (0.68)	N=2.87 (0.50)
N=non-white, n=69	W=3.77(0.94)	W=3.08 (0.59)	W=2.48 (0.62)	W=2.84 (0.55)
W=white, n=208	NS	NS	NS	NS
Low Income	L=3.60(0.97)	L=3.06(0.58)	L=2.50(0.70)	L=2.87(0.56)
L=low income, n=60	N=3.76(0.98)	N=3.09(0.58)	N=2.50(0.61)	N=2.84(0.53)
N=non-low income, n=217	NS	NS	NS	NS
First Generation	Y=3.53(0.95)	Y=3.10(0.57)	Y=2.56(0.58)	Y=2.84(0.46)
Y=yes, n=59	N=3.78(0.98)	N=3.07(0.58)	N=2.49(0.64)	N=2.85(0.56)
N=not, n=218	NS	NS	NS	NS

Attend In-Person	Y=3.86(0.95)	Y=3.09(0.56)	Y=2.47(0.60)	Y=2.79(0.54)
Y=mostly yes, n=168	N=3.53(0.99)	N=3.05(0.61)	N=2.54(0.67)	N=2.82(0.54)
N=mostly no, n=114	**p<.006**	NS	NS	NS
Synchronous Participation	Y=3.77(0.96)	Y=3.06(0.58)	Y=2.48(0.65)	Y=2.83(0.53)
Y=mostly yes, n=225	N=3.58(1.05)	N=3.14(0.55)	N=2.58(0.57)	N=2.89(0.56)
N=mostly no, n=56	NS	NS	NS	NS

Note: NS=nonsignificant difference (at alpha=.05 level) in independent samples t-test

Table 2 shows that no significant difference was found on any of the four variables of interest for marginalized versus dominant identity students in all demographic identity categories. For example, students from lower-income backgrounds did not report statistically different responses to belonging, teaching, social, and cognitive presence constructs compared to students from higher-income backgrounds. These findings suggest that the course provided a potentially equitable environment for learning for all students. On the other hand, qualitative data show nuances to students' sense of belonging across identity groups, revealing some more nuanced disparities in belonging for groups, which continued qualitative analysis will address.

Additionally, given the different options for how students could choose to attend class, we examined differences for students who physically attended versus virtually, and examined responses for those who attended synchronously versus asynchronously. Table 2 shows that the only statistically significant difference in reported student experience was a stronger sense of belonging for those who attended in-person versus online. Online and in-person students reported no difference in any of the three CoI constructs. This result reinforces the necessity of instructor awareness of the impact course structure and delivery could potentially have on student sense of belonging. There were no differences in responses for any of the outcomes for students that participated in class activities synchronously versus asynchronously.

The results of no difference for synchronous versus asynchronous participation suggests that the instructor was successful enough in course organization and delivery that even the asynchronous students who watched the recorded video on their own time were as satisfied as the synchronously participating students. Overall, in some of the qualitative findings, students reported that the class was one of the most organized, inviting, and interactive classes in their limited experiences at the institution. Thus, the class might serve as a model for future hyflex practice in engineering. One student noted, "I think [the class under study] in the engineering portion is where I feel the most connected."

5.2 Response comparison on CoI to comparison group

We also compared responses to CoI constructs between Fall 2020 students and a comparison group reported in the literature [27] by the developers of the CoI survey (see Table 3). Those in-person comparison students were graduate students in the fields of education and business. Because the comparison groups is from a different population than first-year engineering students, results of this comparison should be interpreted cautiously.

Table 3. Comparing CoI construct ratings between Fall 2020 cohort with responses from a comparison group prior to the COVID-19 pandemic

	Outcomes Mean(Standard Deviation)		
	Teaching Presence (scale=0-4)	**Social Presence** (scale=0-4)	**Cognitive Presence** (scale=0-4)
Fall 2020 cohort (COVID-impacted) (n=282)	3.07(0.58)	2.50(0.63)	2.84(0.54)
Comparison group [29] Pre-COVID (n=287)	3.34(0.61)	3.18(0.5)	3.31(0.60)
p-value & Cohen's *d* effect size[a]	p<.001 d=0.46 (medium effect size)	p<.001 d=1.1 (large effect size)	p<.001 d=0.87 (large effect size)

[a] Interpretation of Cohen's *d* of effect size (0.2=small, 0.5=medium, 0.8=large) taken from [32]

Results shown in Table 3 indicate that, although there were no significant differences amongst students within the same Fall 2020 cohort, collectively *all students in our Fall 2020 cohort were negatively impacted* by the hyflex instructional format compared to a pre-COVID group (made up of different students in a different context). When individual identity groups (e.g. low income and non-low income, or women and men, etc.) were independently compared against the literature-reported comparison group ratings, the same pattern of results were found as is true for the entire group altogether as reported in Table 3. As shown in Table 3, the CoI construct of social presence was the most negatively impacted (largest effect size) contrasted against the external comparison group, followed by cognitive presence, with teaching presence being the least impacted, though even teaching presence was significantly lower for the COVID-impacted Fall 2020 cohort relative to the comparison group. Initial assessment of qualitatively collected data shows rather consistent alignment with the quantitative data showing low social presence Many students in focus groups shared comments, such as "I didn't get to know anyone from my community," and "I couldn't make any new friends."

Teaching presence, on the other hand, represented the highest subscale score (out of the three different CoI constructs), which aligns to the mostly-positive ways in which students described the instructor's ability, work, and care to effectively adapt to converting a traditionally physically-attended course curriculum to a remote/hybrid delivery. Preliminary coding of qualitative data has already highlighted several trends regarding the course instructor's attention to three course factors, described below, which positively contributed to student learning and belonging by minimizing some of the potential negative effects of the COVID-necessitated shift to hyflex instructional delivery.

6. Future Work

Analyses of the data are ongoing, and future work will entail continued integration of quantitative and qualitative results to answer research questions in nuanced ways. Future logistic regression analyses will allow us to test relationships among the variables of interest, and comparison of belonging between the fall 2020 cohort and prior (pre-COVID) cohorts of first-year engineering students at our institution will provide a better-matched comparison group to

extract potential implications of COVID on fall 2020 students. Focus groups data also reveal nuances in sense of belonging for students with diverse identities that were not reflected in quantitative data, and continued qualitative analysis will contribute to our understanding of those nuances. Continued analysis will finally result in implications for designing hyflex and other remote courses, fostering sense of belonging for diverse students in STEM fields and mitigate any potential negative impacts of future remote-delivery instructional modes.

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