Is This the Real Life? Exploring How Virtual Learning Environments Influence Engineering Identity

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***Abstract*— This full research paper explores how the remote engineering education environment influences the ways students come to see themselves as engineers. We answer the research question "What aspects of the remote engineering education environment support or fail to support undergraduate engineering identity development?" Participants included 32 freshman and sophomore students during the fall and spring semesters of 2020. Focus groups used a semi-structured protocol to encouraged participants to reflect on their identities, motivation, and success. Participants' experiences with the remote education environment organically emerged throughout the focus groups and were analyzed using directed content analysis to develop codes and themes. The analysis was guided by a conceptual framework that considers figured worlds, communities of practice, and engagement with the environment. Two themes emerged and emphasized the physical and social environment as influential to identity development. Both themes were connected by a subtheme of realness in which participants described the online education environment as not feeling real and hard to engage with.**

Keywords—Online education, environment, identity

I. Introduction

This full research paper aims to explore how the virtual education environment influences the development of undergraduate students' engineering identities. As higher education made necessary shifts to remote learning due to the COVID-19 pandemic, engineering educators wrestled with ways to teach and support students effectively. With the rapid change to virtual education, curriculum design often prioritized the teaching of course content at the expense of practices that also supported engineering identity development. Engineering identity considers how students take on the role of an engineer [1] which influences how they learn, are motivated, and persist through an undergraduate engineering program [2]–[4]. How students start to see themselves as an engineer and its implications, have been a topic of continued interest in engineering education [5]. Identity researchers have been encouraging the inclusion of practices that support the development of these identities alongside the teaching of course content [6]. After the pandemic is over, aspects of remote engineering education are likely to continue as online education becomes more widely spread. The pandemic-induced switch to remote education revealed that some of the default teaching methods implemented by many professors may need to be adjusted to better support student identity development.

There is ample research on online higher education and engineering-specific online research is a growing field. Much research on online engineering education includes but is not limited to the use of a new virtual tool [7]–[9], the effectiveness of teaching specific topics online [10]–[13], or the general benefits and struggles that go along with using virtual programs for a field that is traditionally hands-on [14]. Within online engineering education and, more broadly, online education, there is a noticeable lack of research that considers the development or maintenance of identities. For online engineering programs to fully support students as they learn to become engineers, more work needs to be done that explores how to support the development of engineering identities virtually.

Online education is specifically designed to be taught using a virtual format while remote learning refers to teaching classes designed for an in-person format but administered virtually. The COVID-19 pandemic caused engineering universities to switch to remote learning which used the online and virtual environment to teach classes that were traditionally face-to-face. The use of remote learning presented an experiment of convenience which allowed defaults of online engineering education and their relationship to identity development to be more visible. Although the results from this study center on students' experiences transitioning to remote education rather than online education, it is one of the first to consider engineering identities in a virtual setting and has transferable findings for future curriculum development that aims to support identity development. To address this need to understand identity development through virtual education, the following research question was examined:

1.) What aspects of the remote engineering education environment support or fail to support undergraduate engineering identity development?

This question was qualitatively examined through undergraduate engineering students' shared experiences with remote education during the COVID-19 pandemic. Two emergent themes are discussed, along with a unifying conversation of realness from participants.

II. Conceptual Framework

For this paper, we leveraged three inter-related theories to explore how students' environments, particularly virtual learning environments, can aaffect engineering identity development. The study of engineering identity has been a popular topic in engineering education. Recently, there has been a call to consider the ways environment and context influence engineering role identities [5]. Conceptualizations of engagement are leveraged along with figured worlds and communities of practice to highlight the importance of the environment for engineering role identity development. This combined theoretical framing allows us to examine the ways identity supporting practices have or have not been incorporated in remote engineering curriculum.

The development of an engineering identity can be supported or undermined based on environmental factors, including but not limited to physical spaces and social interactions [15], [16]. Here we focus on the physical and social aspects of the engineering education environment. The physical environment includes the artifacts, tools, and objects both in-person or virtually that can provide an opportunity to practice an engineering identity [15]. Social environments include interactions with people at a particular place and time and can foster identity development through recognition and validation [16]. Engagement considers the interactions with both of these elements of the environment and ties notions of self to constructing relationships with others in particular settings through particular practices [17].

The application of figured worlds and communities of practice to study engineering identities further supports the assertion that the environment can impact engineering identity development [15], [18]. Separate engineering places, worlds, or communities for students to imagine different versions of themselves have been emphasized as crucial for developing these identities [19]. Participation in engineering communities through social interactions allows students to recognize and be recognized as someone who can do engineering [6]. Cultural rules of privilege and power embedded in the engineering environment influence who is seen as an engineer for different practices or types of engagement [20], [21]. In this study, the elements of communities of practice and figured worlds that emphasize the environment are operationalized in a conceptual framework to explore the development of engineering identities through remote education.

III. Methods

This paper reports qualitative results from a larger, ongoing NSF-funded mixed-methods study [NSF grant #EHR-1833738] that focuses on a cohort model designed to support low-income, high-achieving students [22]. The findings discussed in this paper emerged from an exploratory phenomenological study that seeks to understand participants' lived experiences as they navigate an undergraduate engineering program.

A. Location and Participants

This study was conducted at a large, western land-grant, R1 university and focused on the lived experiences of two 16-student cohorts of undergraduate engineering students (32 students total). Participants had voluntarily applied to the four-year, scholarship-based cohort program before starting their first year and were selected based on financial need, academic ability, and letters of recommendation. Data collection for Cohort 1 began in the Fall of 2019 and included the participants' first three semesters in an engineering program. First semester classes were conducted in-person. The second semester included the switch from in-person classes to remote learning due to the COVID-19 pandemic. Third-semester classes were conducted using a combined format that included both in-person and online elements intended to be adaptable as the pandemic situation changed. Data collection for Cohort 2 started in the fall of 2020 and included participants' first semester in an engineering program in which classes were conducted using a combined format. The results presented in this study are pulled from the fall and spring semesters of 2020, both semesters using either remote or combined instruction. The online (remote) portion of student classes typically involved pre-recorded lectures or non-interactive live lectures. There were exceptions but many professors were not proficient in modes of online or hybrid education that may have leveraged opportunities for hand-on experiences, active learning, or interaction. *Table 1* lists participants' pseudonyms, self-reported demographic information, and major at the time of the last interview. This sample's composition supports the transferability of the findings to similar populations enrolled in undergraduate engineering programs who experienced remote learning.

B. Data Collection

Tenants of phenomenology were leveraged as it supports understanding the essence of lived experiences through the embodied knowledge and perceptions of participants [23]. Semi-structured focus groups were used to collect data as they facilitated sharing group experiences that were important to the larger study about cohort interactions [24]. Focus groups consisted of four to five participants, lasted about one hour, and were conducted at the end of every semester. Data included in this paper contained two sets of focus groups for Cohort 1 and one set of focus groups for Cohort 2. The first author led most focus groups, with the second or last author as a secondary interviewer and notetaker. Focus groups for spring and fall of 2020 were held via the online video platform Zoom. All focus groups were audio and video recorded, professionally transcribed by Rev.com, and checked for errors before being uploaded to NVivo 12 (QSR International).

The open-ended nature of focus groups allowed for follow-up questions and permitted the researchers to gather rich detail about participant experiences. For focus groups held during the Spring of 2020, no questions were asked that directly enquired about participant experiences with remote education due to the pandemic. Despite this, participants frequently and freely included their experiences with the switch to remote education. They had a difficult time disentangling these experiences when talking about their motivation, learning, and identity. During fall of 2020, a specific question was added that asked participants to reflect on how the pandemic influenced their educational experience. Table 2 presents a few of the questions asked of the participants during the focus groups.

C. Data Analysis

Directed qualitative content analysis facilitated examining participants' experiences with pandemic-induced remote

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education while leveraging existing identity theory. Qualitative content analysis is an approach used to understand the study of a phenomenon as it lends itself to interpreting textual data of participants' lived experiences through codes and themes [25]. Directed or deductive qualitative content analysis applies and extends existing theory to different contexts or situations.

First, transcripts were coded using an inductive first pass to categorize the data. This coding method is suggested for longitudinal studies or ones with large quantities of data [26]. All transcripts were team-coded by the first, second, and last authors using a codebook developed by coding the first set of focus groups in Fall 2019. Additional codes have been added to understand participants' experiences with remote education due to the COVID pandemic. The relevant codes for this paper are described in Table 3.

Finally, the codes underwent a second deductive pass by the first author. This pass considered patterns of experiences across the coded data to help develop underlying themes [26]. Directed qualitative content analysis facilitated the generation of these themes in which relationships between codes are systematically identified using existing theory as a guide [27]. Themes were shared with the second and last author, discussed, and adjusted based on student experiences and connections to existing theory.

Table 1: Participant pseudonym, self-reported demographic information (Major acronyms: BME = Biomedical Engineering, CE = Civil Engineering, CHE = Chemical Engineering, CSE = Computer Science and Engineering, EE = Electrical Engineering, ENV = Environmental Engineering, ME = Mechanical Engineering, MSE = Material Science and Engineering)

Cohort 1			
Psdeudonym	**Sex**	**Race/Ethnicity**	**Major**
Michael	Male	Hispanic	CE
Jim	Male	White	ME
Kevin	Male	Asian	CSE
Karen	Female	Asian	CE
Andy	Male	Hispanic	BME
David	Male	Hispanic	ME
Toby	Male	Hispanic	EE
Roy	Male	White	EE
Stanley	Male	White, Middle Eastern	ME
Gabe	Male	White	CHE
Pam	Female	White	ME
Erin	Female	White	CSE
Darryl	Male	White, American Indian	ME
Oscar	Male	Asian	EE
Todd	Male	Hispanic, White	CSE
Kelly	Female	White	MSE
Cohort 2			
Psdeudonym	**Sex**	**Race/Ethnicity**	**Major**
April	Female	White	BME
Leslie	Female	White	CHE
Ann	Female	Hispanic	CSE
Derek	Male	White	ME
Sebastian	Male	Asian	CSE
Diane	Female	White	ENV
Ron	Male	White	CSE
Ben	Male	White, Hispanic	EE
Donna	Female	White, Chamorro	ENV
Chris	Male	White	CSE
Tammy	Female	White	BME
Jerry	Male	White	ME
Craig	Male	Vietnamese, Israeli	ME
Mark	Male	White	CHE
Tom	Male	White, Chinese	CSE
Jeremy	Male	White	CSE

Table 2: Codes used for the thematic analysis presented in this study.

Focus Group Question	Target Information
Do you see yourself as an engineer?	Identity
Have the ways you view yourself as an engineer changed since last semester?	Identity development
How has the pandemic influences your educational experiences?	Remote education
How has the pandemic influenced your cohort experience?	Remote education

Table 3: Codes used for the thematic analysis presented in this study.

Code	Definition	Example
Physical Environment	Participant mentions how there physical location influences their education.	*"I think the environment has a lot to do with it. Here in my room, I could do my classes, but it's definitely not the same as in-person."*
Social Environment	Participant describes wanting or having social interactions with peers and faculty.	*"I think a big part of engineering is being interactions and teamwork and stuff..so the lack of communicating with your professors or fellow engineering students and the alternating lab times, that can be difficult."*
Identity	Participant explicitly mentions how online-learning influences how they see themself.	*"It's really different right now. It's hard to even answer that question. Sometimes I do feel like an engineer...but even then I feel like I'm still in high school sometimes."*
Realness	Participant describes the real or authentic nature of an experience.	*"If this was a real class, you'd actually be working with physical breadboards actually doing this stuff and we're just using online programs to basically just simulate it and it just doesn't seem real."*

IV. Results

This paper reports the findings regarding participants' lived experiences regarding remote learning as a result of the COVID-19 pandemic and the development of their engineering identities. The analysis and interpretation of results indicated two major themes centered around the environment: physical places/classes and social interactions. Each theme will be described along with participant examples that illustrate the theme, how their identity was affected, and what curricular activities influenced participants' perceptions of the environment. Additionally, the themes are interconnected through the common element of realness. Participants highlighted how different ways of engaging with the environment did or did not make education feel real or authentic.

A. Physical places and classes

Participants described how the changes in physical environments caused by the pandemic impacted how they engaged with their engineering education and saw themselves as engineers. When asked about her experiences with remote education, Tammy reflected that "*everything being online, it definitely has taken away a lot because it takes away that feeling of being in school, because I just feel like I'm sitting on my computer all the time (Fall, 2020).*" When comparing on-campus versus remote education, Roy also highlighted the difference in realness between both experiences:

"[when on campus] you actually feel like you're doing something, and when it's online, it feels like you're just watching YouTube videos of how to do it, and then you just do it and then move on. It doesn't feel like college. So it's been a little harder to get excited over the material and stuff when it doesn't feel real (Fall, 2020)."

The importance of physical places extended to how participants felt about their own engineering identities. Participants described how being in places they associated with engineering or learning permitted them to feel like an engineer, as is the case with Karen: *"last semester, I felt more of an engineer when I was in an actual classroom but being at home in front of a screen doesn't really make me feel like it (Fall, 2020)."* Craig also highlighted how a lack of physical engineering places influenced his engineering identity: *"Not being on campus is a little weird, I [think of being] a scholar as being an engineer but I don't feel scholarly when I'm sitting at home and watching lecture, taking notes and stuff like that (Fall, 2020)."*

Asynchronous classes in which prerecorded lecture videos were used exacerbated the disconnect from the physical classroom setting. Participants in classes conducted with this method often lamented that *"teachers would just post videos and say, 'watch this at some point (Pam, Fall 2020),'"* rather than conduct a real-time class. Participants seemed to be more engaged with their engineering education and view school as real in classes that were conducted in real-time and incorporated interactive elements. For our participants, additional authentic engagement frequently occurred through their cohort program, as described by Erin: *"I've been having problems with classes don't feel real. So [the cohort] made the whole thing feel much more real since everything's gone online (Fall 2020)."* Additionally, participants described how the cohort structure and regular virtual meetings made school feel like it was really happening despite not having the rhythm of getting to campus and going to classes.

B. Social Interactions

Regarding the social environment of remote learning, participants described feeling cut off from their peers and professors in many classes. Oscar describes the feeling of solitude he experienced through remote learning: *"That did feel kind of lonely sometimes. Especially during the COVID era, with online learning and everything. You can't really interact with people, so I get that feeling, sometimes you're kind of on your own (Fall 2020)."* This social disconnect with peers influenced learning as participants described how they struggled to leverage their classmates online as presented by Sebastian:

"In in-person classes, when we don't understand something from the literature, if we have any little confusions, we can discuss with our peers and get rid of those confusions. But in online, it's sometimes in a class of 200 people….It kind of feels uncomfortable. When those little confusions pile up, that creates a problem." (Fall, 2020)

Participants also emphasized the difficulties developing connections with peers which led them to worry that their lack of relationships will influence their ability to form project or study groups in the future. Kelly describes this shared concern: *"I know, going forward, I'll need people to bounce ideas off of and work on projects with. But I don't think I know anyone in my major really (Fall 2020).*" Co-curricular groups facilitated opportunities to meet engineering classmates outside of class time. Darryl mentioned how for him, not knowing people was not as big of a concern since *"between [the cohort] and Honors and some of the other stuff I've done, I've met enough people that are in my classes, that it's not just reaching out to strangers (Fall 2020)"* but that other students "*had to make online spreadsheets and everything and really try to interact with people in order to just get groups together to do stuff (Fall 2020*)." In addition to co-curricular groups, participants described how the creation of class-specific group chat rooms allowed them to meet and engage with other students as well as collaborate on things like "*studying for finals or perhaps debugging issues (Kevin, Fall 2020)."*

Participants highlighted how interacting with peers influenced how they saw themselves as engineers. April made connections between her engineering identity and the social environment by centering her perceptions of how she saw herself with interactions with peers: *"It doesn't feel like I'm even in college sometimes…I feel like I would feel more like an engineer right now if I was able to go to classes and talk to other people (Fall 2020)."* The importance of social interaction for identity was shared by Todd, who said, *"[online learning] hasn't helped me feel like an engineer as much this semester mostly because there's not really as many people around you to recognize what you are doing (Fall, 2020)."* Ann extended this conversation about identity and social environment by emphasizing the importance of group work to being an engineer. Ann explains how not working with peers affected how she saw herself:

"Being off-campus has kind of made me feel not as much as an engineer because if you think about it, engineering comes with a lot of teamwork, and like April was saying, we weren't really able to work with our groups as much as we could have (Fall 2020)."

Participants also described a social disconnect with some faculty members. For many, it was the lack of in-class interactions hindered by the pre-recorded video lectures that limited the ability to ask questions or, in the case of Kevin, "*to walk up to after class or just interact…being able to talk to a real person."* Others, like Stanley, described how *"professors aren't necessarily as available, or they don't feel approachable as it was in person"* and particularly highlighted the difficulties in reaching professors during office hours. Participants also described the anxiety caused by interacting with faculty using video chats and how they have not utilized office hours as much this semester. Kelly added that the lack of face-to-face interaction with professors made *"this semester going into it…it's like not even real (Fall, 2020)."* However, participants mentioned how virtually interacting with professors was much easier when they had previously interacted with them in-person as presented by Pam:

"I had already interacted with my professors, and I knew them. So it's a little less awkward doing that. But these professors I've never met this semester because we've been online the whole time, and for some professors, they have prerecorded lectures. So I've never even met this person (Spring, 2020)."

V. Discussion and implications

Three suggestions are presented to start imagining ways environment and engagement can be supported so that engineering identities can be better developed through online education. Many of these suggestions are already used in online engineering education both before and during the pandemic but this section aims to reframe them in respect to supporting identity development. Participants described varying degrees of engagement with their virtual engineering environments and had classes other than non-interactive, pre-recorded lecture. Rather than imply that no professors implemented any useful tools in their curriculum, these suggestions are meant to highlight what specific aspects should be continued, added, or built upon depending on faculties current online methodology.

A. Virtual Classroom Environments

The development of engineering identities occurs in environments that support engagement and social discourse [15]. Participants in this study often lamented how the lack of in-person classes and limited interactions with peers made school feel unreal and promoted a disconnect from their education. For online education to support students as they develop engineering identities, virtual environments need to be created and implemented to replace traditional physical environment so students have spaces to imagine and practice perceptions of self. These socially and culturally constructed places provide the context for meaning-making and self-understanding through social dialog and practicing an identity in figured or imagined environments [15]. Although these worlds and communities can form naturally, they may need to be purposefully created and maintained in specific educational spaces. Online engineering education could create virtual figured worlds or communities of practice so that engineering identities can still develop through interaction and engagement without being tied to a physical location like a classroom or college campus.

Participants noted that simply watching prerecorded, broadcast lectures or logging into a video class in which they do not interact was not enough for participants to feel like they were in school or for school to feel real. Authentic or real engagement with virtual environments is needed for engineering identities to develop, the described disconnect hindered students in starting to see themselves as engineers. Massive Open Online Classes or MOOCs have been utilized for engineering classes, but interactive elements need to be further incorporated so students can engage with the material and learning environment [14]. For engineering identities to be supported, there is a need to shift from the currently implemented broadcast style learning to more interactive learning [28]. While physical classroom settings reinforce interaction, for web-based tools to be efficient in supporting learning this interaction must be purposefully scaffolded. Although a significant advantage of online education is the ability to work at one's convenience, the lack of social interaction further causes a disconnect between the students and the education environment [14]. Classes could be conducted in real-time and emphasize active engagement with the material and each other through active learning exercises. These exercises may use virtual collaborative spaces like Google's JamBoards, discussion chatrooms like Slack or Discord, and video chats with smaller groups of students. Online engineering classes designed around interaction and engagement with the material and peers also support engineering identities and should be emphasized in curriculum design.

Participants also described how sitting in their bedroom isolated from their peers kept them from feeling like students or engineer. Social presence theory has been used in engineering education to explore how students feel they are perceive and perceive others as "real students [29]." By operationalizing practices that helps students feel intimately and immediately engaged with the people in their social environments, virtual curriculum may better support engineering development. Virtual representations of the classroom where students exists as more than a name under a black screen such as Together mode in Microsoft Teams, Second Life, or the Gather Town may create spaces to develop virtual social presence [30]. Again, the use of these virtual environments needs to also act as a place to interact and engage if they are to be effective; otherwise, they are simply another thing to log into to watch broadcast-style lectures [28]. These tools will not wholly replicate being in a physical classroom and fulling engaging with peers and faculty, but they may promote the feeling of going to class, being in an engineering or scholarly space, and seeing themselves and others as real students. These suggestions are just a small portion of the substantial body of literature for online education but highlight certain elements that may specifically support identity development.

B. Promoting professor engagement

Participants often mentioned how they felt extremely disconnected from most of their professors both in and out of class. Social environments are a considerable aspect of both figured worlds and communities of practice as identity forms through dialogue in which people position and are positioned as certain types of people, here as engineers [15], [16]. Within communities of practice, there is an emphasis on the role of knowledgeable members who help bring novice members into the community as they learn the practices of the community [18]. In an engineering classroom, this knowledgeable member would be the professor who is helping integrate the novice students. If students feel like they do not know the professor or cannot communicate with the professor, the development of an engineering identity may be hindered. Professors must effectively engage with students during class and office hours so that they are able aide in the integration of students into the engineering community of practice.

Faculty members typically feel online education promotes social interaction, but this belief is not shared by engineering students [31]. Participants mentioned that prerecorded videos and classes with no interaction made it difficult to ask questions and clarify their understanding. Professors could be holding classes in real-time and could include opportunities to ask questions during the class rather than waiting until the end [32]. During the spring semester of 2020, participants had a chance to interact with their professors before going online in March. Participants described how they felt more comfortable interacting with these professors in the following months since

they had a chance to meet them before going online. This comfort did not extend to the Fall semester, where students did not have an opportunity to meet or interact with their professor other than through watching them give a video lecture. Work on online engineering education encouraged a beginning of semester in-person meeting between the student and the professor to support future interaction [33]. A chance to informally interact with individual students or small groups of students may reduce the hesitancy to interact with the professor in class.

In addition to class interaction, this discomfort extended to virtual office hours. Many students said the video chats with a professor they had never met was uncomfortable so they used this resource less often. Early semester introductions may also enable students to interact with the professor during office hours as well as in class. Many students described the reluctance to join a video chat where they may be the only student in attendance. Holding discussion chatroom office hours with the option of video chats may also allow students to ask questions in a real-time format without the initial barrier of joining a video call [34]. Small adjustments to increase the accessibility of the professor may help provide valuable interaction with knowledgeable members of the engineering community as students develop engineering identities.

C. Cohorts

Classes and engineering programs could also implement cohort models to support students. Participants in this study were in their first or second year of a four-year-long cohort and described how the participation in the cohort during the COVID-19 pandemic made their education experience feel more real. Where the current version of remote education led to a disconnect between students and the learning environment, participation with the cohort promoted engagement with their engineering program through social interaction with peers and faculty. They commented that the structure of the cohort which fostered interaction and socializing allowed them to feel like they were part of a community of engineers despite not being supported in their engineering classes.

Research shows many benefits of cohort models for students as they help create social environments for students to interact and form relationships [22]. The incorporation of cohorts into online learning may prove an effective way to promote engagement both with the material and with each other as students developed a community build around shared experiences and common interests. These smaller cohorts allow the ability to interact with peers in an environment that is more accessible than a large, virtual classroom and may act as an extension of the suggested virtual environments by working as a larger community of practice. In addition to supporting the development of engineering communities, student engineering identities may also be fostered by participation in these cohorts [35]. Cohorts may be beneficial for permanently online engineering education programs as well as for engineering education in an uncertain future where classes may switch between online and in-person learning due to forces beyond the institutions control. During the COVID-19 pandemic, participation in a cohort helped stabilize participants' experiences and gave them structure and social interaction for identities to develop within and around.

VI. Limitations and Future work

This study presents novel work on environment and identity development through remote education and virtual formats, but it is not without limitations. These results emerged from a larger project seeking to understand identity, motivation, and success through participation in a cohort. The larger project's aims did not include the exploration of the intricacies of remote education and engineering identity development. Rather, what participants said about their experiences with remote learning during a pandemic was hard to separate from answers to any question. Future work should specifically seek to explore the influence of both physical and social environments in online engineering education and how the development of engineering identities are or are not supported.

Furthermore, the participants in this study were forced into remote education due to a pandemic. The programs they entered were not specifically designed for online education, their professors were not prepared to teach online, nor were the participants choosing this educational format. Their answers may have a negative bias due to circumstances and the fact they did choose this method of higher education. Future work should investigate the impact of the environment on engineering identity development for students who willingly enrolled in an established online engineering program.

The data captured in this study focused on classes that were traditionally lecture-oriented or conducted by professors who may provide the same limited amount of engagement opportunities even if they were in-person. Future work may need to consider professor perceptions to understand the full picture of how engagement with the environment is facilitated. Additionally, preliminary analysis of data collected during the spring of 2021 suggests that some classes did offer substantial opportunities for engagement with the course content and with peers. Future work that evaluates how the environment supports or fails to support the development of engineering identities should specifically consider classes that purposefully promote virtual engagement to determine their impact on identity.

The conceptual framework used in this paper considered aspects of the virtual learning environment in support of identity development. Findings showed that the relationship between engagement with the social environment and things feeling real influences how students saw themselves as engineers. This relationship may be further explored using social presence theory in which people feel others perceive them and they perceive others as “real people.” This theory has been applied to online engineering education and may be a valuable perspective in exploring the relationship between realness and identity development in virtual learning environments [29].

While the participants in this study were academically talented and demonstrated financial need, these factors were not explicitly considered in this analysis. Although the population is relatively diverse in terms of gender, race, and educational background, additional social identities should be examined to determine the disparities in how remote and online education supports or undermines identity development. The suggestions presented are baseline ideas for practice that require additional

research to determine their effectiveness for diverse student populations

VII. Conclusion

A conceptual framework considering engagement with the physical and social aspects of the environment was used to guide data collection, analysis, and the interpretation of findings. Focus groups were used to capture participants' experiences with engineering remote education due to the COVID-19 pandemic and the unplanned shift to virtual teaching methods. Findings emerged from questions about identity and motivation from a larger study and resulted in two major themes that were connected by a story of realness. The role of physical places and social interactions were highlighted as influential in the development of engineering identities. School needed to feel real for participants to feel like they were able to engage with the physical and social environments so that they have spaces to practice and develop engineering identities. These results extend existing work on engineering online education and present a new perspective by considering the development of engineering identities.

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