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Board 424: Using Badging to Promote Makerspace Participation and Engineering Identity Development: Emergent Themes and Lessons Learned from a Pilot

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Abstract: Engineering identity development is crucial for engineers' professional performance, personal fulfillment, and organization's success. Various factors including recognition by others, interest, and competence can affect the development of engineering identity. Participation in engineering-related activities, such as involvement in makerspaces, can lead to increases in engineering self-efficacy and can provide opportunities for students' to be recognized as engineers, potentially promoting the development of their engineering identity. However, participation in makerspaces is not necessarily equal across all student groups, with the potential for white, man-dominated cultures of engineering to be replicated in makerspaces, preventing students from marginalized groups from feeling welcome or participating. Earning microcredentials and digital badges in makerspaces has the potential to encourage participation and provide a means for recognition. The goal of this two-year project (funded by NSF's PFE: Research Initiation in Engineering Formation program) is to study engineering students' engineering identity development and how makerspaces and digital badges can contribute to this development process. Towards this goal, we interviewed a diverse cohort of eight first-year engineering students at a large, land-grant, Hispanic-Serving Institution in the U.S. during the Fall 2022 semester. Students participated in two one-hour interviews at the start and end of the semester on topics including their making skills, experiences in the makerspace, participation level in groups, perceived recognition as engineers, and feeling of belongingness in the engineering community and makerspaces. This paper presents lessons-learned from the interview implementation process, including dealing with disruptions from the ongoing pandemic and traumatic campus events. We also present emerging themes from qualitative analysis of the interviews. We expect the implications of this work to guide instructors and administrators in developing more motivating and interactive engineering courses and makerspace experiences for diverse students.

Keywords: Engineering identity; sense of belonging; digital badges; makerspaces

Introduction

The development of engineering identity is a vital goal of engineering education. Engineering role identity, a subject-related role identity framework related to students' performance, interest in subjects, and perceived recognition by others [1], is important because it can impact students' persistence and retention in engineering [2]. The extent to which someone feels like an engineer can be impacted by other identities such as gender and race/ethnicity [3]–[6]. Prior work shows that engineering identity development can vary among students of different genders and other identities, and indicates that women and students from marginalized races/ethnicities may face challenges in developing an engineering identity due to longstanding inequalities in representation and an exclusionary culture [4], [7]. Identifying ways in which all students, regardless of race or gender/ethnicity, can develop an engineering identity and feel that they belong in engineering, may lead to better retention of diverse student populations.

In this study, we explore the potential of digital badging in makerspaces to promote engineering identity development and creation of a sense of belonging in engineering. Engineering-related experience and engineering-related connections can provide opportunities for engineering identity development [8]. One potential space where students can participate in engineering-related experiences is makerspaces. Makerspaces enable students to feel associated with the engineering profession and develop engineering identity by giving them the opportunity to experience common engineering tasks (e.g., prototyping, experimentation, and design) [9]–[11]. Researchers suggest that makers and engineers have intersecting educational pathways, and creating maker identity formation pathways for students could help broaden pathways to engineering [9], [12].

However, engagement in makerspace activities is uneven among students of different genders and groups. There may be a tendency for makerspaces to duplicate engineering culture, where students from women and students from marginalized races/ethnicities do not feel that they belong [13]–[15]. However, researchers have begun to identify best practices to promote inclusion and diverse participation [16]. Because digital badging programs can promote personalized learning and skills recognition [17], digital badges may be effective in developing engineering identity in students, helping to promote recognition and interest, two constructs involved in engineering identity. Earning digital badges could also encourage more participation in the makerspace, which could in turn lead to increases in engineering identity development and sense of belonging. Microcredentialing in makerspaces may have the potential to encourage participation in makerspaces and to develop engineering identity and belongingness in students for diverse student populations.

To explore the effects of digital badges and makerspaces engagement on engineering identity development, we have undertaken a two-year project that involves implementing a digital badging system and both quantitative and qualitative data collection. In this paper and poster, we describe some preliminary results from our pilot implementation in Year 1 of the project. We interviewed eight first-year engineering students with diverse gender and racial backgrounds. All our participants were enrolled in an Introduction to Engineering Design class where they were required to go to the library makerspace and get training on designing and making parts. Students undertook training for 3D printing and 3D computer-aided design tasks in the first half of the semester, and used these new skills in two hands-on, team-based projects that took place throughout the semester. Based on their efforts, they were awarded digital badges. Most participants earned their first badge about halfway through the semester. Our interview questions asked about their previous and current experience of making, their feedback on the badging process, their experiences in the makerspace, their perceived recognition as engineers by peers, and their sense of belonging in the engineering community. In this paper, we represent the lessons learned from the implementation of the interviews and the emerging themes arising from the interviews.

Lessons learned

Our in-person recruitment for interviews yielded 18 students expressing interest from a class of 44 students (41% volunteer rate). The interested students were diverse in terms of engineering majors, gender, and race/ethnicity. We conducted purposive sampling to downselect a diverse subset of eight participants. To do this, we shared in our invitation that our goal was to recruit a

diverse group, and in our selection process, we strategically oversampled students whose self-reported gender and race/ethnicity identities have been marginalized in engineering to ensure that our subset included diverse identities, as well as traditionally privileged identities. Out of the total of eight participants, four individuals self-identified themselves as man, while three participants identified as women. One participant identified as a woman but was unsure or questioning. In terms of ethnicity, three participants identified as White or Caucasian, one participant identified as Latinx or Hispanic, one as Asian, Desi, or Asian American, one as Black or African American, and two participants identified as both Latinx or Hispanic and White or Caucasian. The engineering majors of the participants were diverse and included biomedical, chemical, electrical and computer, materials science, and aerospace. We conducted two interviews with each participant, one at the start of the semester and one at the end of the semester. The start-of-semester interview scheduling based on interviewees' provided availability proceeded quickly, even though we faced illness-related disruptions during the start-of-semester interviews and finals-week scheduling complications during the end-of-semester interviews. Still, we accommodated student and interviewer schedules, and we conducted all the start-of-semester interviews either in person or hybrid (via Zoom) during the middle three weeks and all the end-of-semester interviews during the final three weeks of the fall semester.

During the Fall 2022 semester, a university affiliate was tragically shot and killed on our campus. The shooting occurred in the building directly next to where the students' Intro to Engineering Design class was held. This event occurred during our first round of interviews. This class was canceled the day following the shooting and campus resources related to mental health and safety were shared. We did not modify the interview protocol to explicitly ask about the event, but were interested to see if students mentioned it while describing their reasoning in choosing when and why to go to the makerspace. No student explicitly brought up the shooting during the interviews, so we cannot comment on the impact of the event.

Preliminary themes and findings

Two interviewers took notes independently during interviews and found several common themes they discussed and agreed upon. This study includes these themes, but more comprehensive coding will be carried out in future work. The identified emergent themes from the interviews are shown in italics and discussed briefly below.

Students had multiple reasons for pursuing badges

Nearly all of the participants said that this was their first time obtaining a digital badge. Despite the fact that all the participants agreed that the badges were relevant to the course's context, they had diverse experiences with the badges: one found it helpful as an introduction to the makerspace's resources, another saw it as a fun factor rather than a motivating factor, and another mentioned it as just another assignment in D2L. About their feelings after getting the badge, one participant said, "I was excited to get the 3D printer certification. The badge was the little cherry on top to prove I was able to use it." Many participants had positive comments about the ease and clarity of the overall badging process. The participants identified some challenges in the badging process, including a superficial 3D printing preparatory review and the distance from the dormitory to the makerspace. Most participants stated that the timing of the badges—during

the middle of the semester—was the reason why they did not receive the advanced badges. Some suggestions/advice from the participants about the improvement of the badging process includes using open-ended badging with no restrictions on time, giving a third badge combining both designing and printing tasks, providing more clarity/instructions on the value of the badges, and working on better integration into the course.

Course requirements and projects motivated students to visit the makerspace

For the majority of participants, their decision to visit the makerspace was primarily driven by the requirement of utilizing its resources for their personal or class projects. Most participants had a positive impression of the treatment and assistance provided by the staff at the makerspace, and also noted the makerspace's diversity and ability to serve various engineering specialties. One positive feedback about the staff in the makerspace was:

> I think the staff was really a positive experience, because when I went…the first time I went in to print something for that class, …I put it in the machine, but something broke. I don't know what was happening.…So, they helped me out with that. I still don't know what went wrong, but they fixed it pretty fast. So I think the staff there, it was like ten out of ten.

A few participants expressed that they do not view themselves as a part of the makerspace community due to their limited visits to the makerspace.

Students felt more recognized as engineers at the end of the semester

During the start-of-semester interviews, we observed that some participants were unsure of their perceived peer recognition as engineers due to their limited experience at that time, while some individuals were more self-assured about their perceived engineering recognition. In the end-of-semester interviews, most participants were positive about the feelings of being recognized as an engineer by themselves, their family, and friends: one participant perceived that his friends knew that they have engineering skills, another participant felt like an engineer when explaining his engineering projects to others, and another participant thought that there was much less shock when she introduces herself as an engineer. For example, on the topic of being recognized as an engineer by peers, one participant responded in the start-of-semester interview saying,

> I don't think we've had enough interactions with each other to see, to say like, 'Hey, this guy is a natural engineer and this guy is not.'

When we asked the same question at the end-of-semester interview, he responded,

> I feel like they trust me to know what I'm doing, if I don't, I'll figure it out. I think that's very engineering, like where you just figure things out.

When another participant was asked if he felt more like an engineer at the end of the semester, the participant replied:

> Yeah, I feel that way. And it's more, like, the faculty and I guess everyone else kind of sees it more. It feels like now everyone's kind of grounded. Everyone kind of knows a bit more of what they want to do at this point, or at least what they're majoring in.

Students' sense of belonging in engineering came from multiple sources

The majority of the participants reported feeling a sense of belonging in the engineering community through their involvement in engineering classes, project groups, engineering clubs (such as the IEEE club and the robotics club), and their dormitory. The dormitory was highlighted as a significant factor in fostering a sense of belonging in the engineering community. A participant living in an honors dorm discussed about how her perceived belongingness in the engineering community differs from a friend who doesn't live in the same dorm, or in any dorm:

> I would say definitely, less connected for sure, there's something about living with people, and just having that camaraderie in a dorm that you can't have anywhere else, and then engineering is so collaborative that you're constantly relying on other people to do your work with…I think I definitely feel more connected to engineering, and those in my dorm than other people who don't live on campus…

Students appreciated the diversity in engineering classes and in the makerspace

Most participants noted a predominance of men in engineering classes and related communities. However, they also highlighted the diversity present in terms of gender, race, and ethnicity, both in engineering classes and in the makerspace. Women participants said that their gender inspired them to excel in their engineering classes. Participants from marginalized race/ethnicity groups noted seeing other individuals of the same race/ethnicity in the engineering community and remarked how seeing them gives them a sense of encouragement.

Students navigated shifting team dynamics

During the start-of-semester interviews about team dynamics in engineering projects, the majority of participants reported that their project groups did not have a designated leader and tasks were assigned based on personal interests, availability, or skill. However, in the end-of-semester interviews, some participants mentioned changes had been made, such as assigning certain responsibilities like submitting team reports or presentations to specific team members. In terms of communication and cooperation within the teams, their feedback on team interactions/experiences was generally favorable. We expect to explore team dynamics more later in the two-year project.

Conclusion and future work

The implementation of our study in the Fall 2022 semester provided useful preliminary information, but for the later implementations, we need to consider students' other communities both in the recruitment process and in the interview protocol. We can get a deeper understanding of the sense of belonging of diverse engineering students in diverse communities. We also learned that the timing of the optional badges can be made flexible to see if the participation level changes among students. Most of our participants chose engineering as a major motivated

by their interests and skills. However, engineering identity formation is a gradual process and is driven by the skills they learn, the recognition they get from their peers/connections throughout the process which we noticed from the interview responses. For example, we noticed some changes in some participants' feelings about being recognized as engineers by peers from the start-of-semester interview to the end-of-semester interview. Projects including fabrication and experiences in makerspaces can help to develop identity and belongingness in engineering. From this set of interviews, it seemed like our campus makerspace environment is diverse and inclusive in terms of gender and racial identity. While the participants found the badging process straightforward, they also provided some possible improvements we can make, like more instructions and details. Experience in the project team can also affect the sense of belonging. We received both positive and negative team stories from the participants. In addition, we found it was not only the engineering classes, clubs, and teams that seemed to affect the sense of belonging, but also where the participants lived. Our preliminary results indicate that students' making experiences, especially in the context of project teams, influence how they feel as engineers. We will continue to explore these themes into the second year of our project.

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