Building an Identity in the Makerspace

Abstract

The purpose of this complete research paper is to analyze the impacts of an open makerspace on the development of students' engineering identities. This paper seeks to build upon current belonging analyses about makerspaces and shift the focus towards students' engineering identities. Our team interviewed 17 first-year engineering students attending a small, private university located in the American southwest. During the interviews, they were asked to reflect on their experiences in classes and involvement in engineering related activities. Some of the interview questions are influenced by previous models of engineering identity.

Our research team noticed a pattern of students spending personal time using the Makerspace in their engineering department. This is an open workshop where students have access to free supplies to do what we've called "make" which is the act of problem solving, designing, and building using the tools provided. The high rate at which this space is mentioned in tandem with the students' successes during the two semesters exemplifies the impact it has on student retention rates. We noticed a trend that students who have strong engineering identities tend to spend time making in the Makerspace.

Any mention of the Makerspace itself or any connective context pieces relating to activities of the Makerspace spoken by the group of students were collected by our research team. This paper will examine how heavy of an impact, if at all, the Makerspace has on the further development of a student's ability to recognize themselves as an engineer if they came into college with an initial interest in making. Our analysis suggests the Makerspace provides an opportunity for students to display performance when making. This in turn causes students to see themselves as engineers when they experience internal and external recognition from being in the Makerspace. The results of this analysis will aid in the creation of effective intervention methods universities can implement during the first year engineering curriculum to increase retention rates.

Introduction

Universities are focused on improving retention rates of engineering students [1]. Existing quantitative research studies statistically correlate retention with high grades in both high school and college and high ACT or SAT scores [2]. With the increasing emphasis on engineering identity being a prominent contributor to the overall success of engineering students [2], it is important to understand why certain students drop their engineering majors and others persist through completing the degree [3].

Numerous studies have proved the link between a strong sense of engineering identity and success in the field [4]. This ties directly into retention rates as students who see their own validity in engineering disciplines are more likely to stay in undergraduate engineering programs [9]. With this in mind, some universities have tried to increase retention rates by creating spaces for students to do what we've termed, "make." Dougherty's [5] universally accepted definition of "making" encompasses traditional trades like woodworking, sewing, and soldering with more modern activities including coding, 3D-printing, and laser cutting [6]. Our definition of "making" is similar, but incorporates more generic skills of building, designing, crafting, and problem solving. These spaces in which "making" occurs can be commonly referred to as "makerspaces." Makerspaces on college campuses serve as physical locations for students to design, fabricate, and make both for class and personal projects [7], [8]. On a deeper level, these spaces allow for students to network, bond, help each other with homework, and strengthen their engineering identities [7].

Makerspaces are varied across universities. Some makerspaces are only accessible while staff is present, whether it be student workers, support staff, or both [7]. Others are swipe accessible to students so that they have 24/7 unsupervised access to the space [8]. Some makerspaces support curricular instruction as a part of helping students become familiar with the tools while others rely on student voluntary participation to learn from the workers [8]. Depending on the engineering cohort size, certain makerspaces are more defined by the community of students who regularly occupy the space [7].

Our study focuses on the role a makerspace within an engineering school contributes to students' experiences and the development of their engineering identity. Therefore, we ask:

> RQ1: *In what ways do students' initial interest in making contribute to the building of their engineering identity?*
> RQ2: *How does an on-campus makerspace used throughout the engineering curriculum further develop students' engineering identity?*

With these analyses, we hope to prove a connection between initial interests in making to the significant use of the Makerspace that in turn has positive impacts on students' engineering identities.

Theoretical Framework Background on Identity

In order to fully analyze the impacts the free use makerspace plays on the development of students' engineering identity, we reference past literature to help guide us. The engineering education community has more recently, in the past two decades, been interested in students' development of their engineering identities. Carlone and Johnson (2007) conducted studies on identity in relation to women of color in science. Their identity framework includes three facets: performance, recognition, and competence. Within their framework Carlone and Johnson defined performance as "social performances of relevant scientific practices,"(p. 1191) recognition as "recognizing oneself and getting recognized by others as a 'science person,'"(p. 1191) and competence as "knowledge and understanding of science content."(p. 1191). Carlone and Johnson recognized that within the recognition facet there are three sub-facets, lack of recognition, social/teacher recognition as well as recognition of self. They identify recognition of self as an intrinsic motivation factor that aids in recognizing oneself as a 'science person.'

We also call upon prior work from Hazari [9] whose research primarily focused on the identities of students in high school physics classes. Within this framework Hazari changed the definitions of recognition to "recognition by others as being a good physics student" (p. 982), performance to “belief in ability to perform required physics tasks” (p. 982), and competence to “belief in ability to understand physics content” (p. 982). Hazari [9] furthered research by expanding Carlone and Johnson’s [10] framework adding a fourth facet, interest, which is defined as the desire/curiosity to think about and understand physics. Hazari [9] was able to show that a student’s interest in a subject, like science, influences the student’s persistence in this subject.

Godwin [11] expanded on Hazari’s [9] research to modify the framework. Godwin developed a survey instrument to measure engineering identity that consisted of three factors which included recognition and interest then clumped performance/competence together to make the third facet. Godwin defines recognition as “feeling that others see them as a good engineering student” (p. 4), interest as the “desire/ curiosity to think about and do well in engineering” (p. 4), and performance/competence as the students’ “belief in ability to perform required engineering tasks and understand engineering content” (p. 4).

Throughout our paper we will be utilizing a combination of the above frameworks to create a four-facet framework that will make up a student's engineering identity. Our definition of recognition is a mixture of all three established frameworks. We determine recognition to be the act of recognizing oneself as feeling like an engineer and/or getting recognized by others as an engineer. Our framework will pull from the existing [9], [10] definitions to specify that performance is the students' belief in their ability to perform and/or showcasing relevant engineering practices. Primarily focusing on Hazari’s [9] definition we determine competence as the students' belief in their ability to understand engineering practices. Lastly we will use Hazari [9] and Godwin’s [11] models to define interest as the desire/curiosity to further explore engineering concepts and practices.

Methods

Positionality Statement

The authors of this paper all have a common interest in how engineering identity plays a role in student retention in engineering. The student authors of this paper are all undergraduates. Two of them are majoring in engineering, one in biomedical and one in civil. The third undergraduate student is majoring in psychology and has no experience in engineering. The other two authors have doctorates in engineering, teach engineering courses, and conduct research in engineering education.

Data Collection

This study originates from a larger study examining first and second year students’ engineering identities and affect [12] while enrolled at a small, private university located in the American southwest. This University has a small engineering program, graduating approximately 35 students per year. At the beginning of their first semester in engineering coursework, students were invited to participate in the two year study, following a protocol approved by the university's Institutional Review Board. The research team selected 17 interview participants based on demographic characteristics submitted through a survey upon their consent to participate in a human subject research study. Students were given the option to select multiple racial/ethnic identifiers, so these numbers total higher than the number of participants: 23 students selected White, 5 selected Hispanic, 3 selected Multiracial, 2 selected Asain, 2 selected Latinx, and 1 did not reply. Along with consenting, the students were also asked questions regarding their overall feelings towards math, science, and engineering as seen in Table 1 below. At the end of each semester, participants were interviewed and asked to reflect on their experiences in classes and involvement in engineering related activities. These interviews tend to be about an hour to two hours long, depending on how much the student enjoys reflecting. Some of the interview questions were geared towards engineering identity. Some were geared towards affect, global affect, and affective pathways [13], [14], [15], [16], [17]. Most of the other questions surrounded the information the student provided in the survey, confirming that all of the boxes they checked match how they truly feel about their attitudes, demographics, and outside identities. We examined evidence from the participants' first and second post-semester interviews with facts from the preliminary survey as contextual support.

This university's makerspace is commonly referred to as "the Makerspace" by the students. The Makerspace consists of multiple rooms connected to one large open seating area. One of the connected rooms is the classroom in which the first semester introductory engineering design course takes place. This course specifically requires students to use the machines in the Makerspace to design and build their final group projects. Another connected room contains tables for students to work at. The other rooms include different workshops for activities like breadboarding, machining, and 3D printing. The Makerspace hires student workers along with professional support staff to mentor students completing their homework or learning how to use the machines. The Makerspace is accessible to all students on campus, not just the engineering cohorts, and is open for extended hours (longer than 9am-5pm). However, students can only use the space when a worker is present. Many students in the group of interviewees identified the Makerspace as a social study space for engineering students. They described pursuing hobbies and working on assignments as a group using the Makerspace and associated rooms. As a research team, we noticed in these utterances that the four pillars of engineering identity (interest, performance, competence, and recognition) were discussed by certain students who spend their personal time in the Makerspace. Just as literature has identified the importance of engineering identity on retention in engineering [2], we wanted to evaluate just how much this universities' Makerspace impacts student identity development that in turn will influence retention.

Three undergraduate members of our research team searched through all the first and second semester interview transcripts looking for mentions of the Makerspace, also searching for a variety of university-specific nicknames for the areas associated with it. Then, we did a deeper look searching for terms related to "making," including "building," "3D printing," and "designing," that implied students were using the Makerspace. After collecting all the quotes, we sorted them into five categories regarding the context of mention of the Makerspace:

1. Generic perspectives on the Makerspace student group. These could be observations made from outsiders or descriptions from students who frequently spend time within this group.

2. Expressions of engineering interest within the Makerspace. This includes spending voluntary time in the space, personal desire to work on hobbies in the space, and overall positive feelings about the Makerspace.
3. Displays of engineering performance and/or competence within the space. These could include but are not limited to completing the design project, descriptions of successful personal creations, and use of tools and machinery.
4. Descriptions of using the Makerspace for class related projects. These tend to overlap with category 2, but are nuanced with students articulating the requirement of using the space for coursework.
5. Utterances showing students feeling a sense of belonging. This also includes describing a feeling of community and positive feelings when spending time with friends in the Makerspace.

Participant Selection

Most students talked about the Makerspace in a descriptive tone that categories 1 and 4 identified above. They gave context to what type of students utilize the tools, what they do in the space, and what kinds of benefits it had on their semester design projects. A number of them also described feelings of belongingness in the space, as identified in category 5. These contextual pieces are useful, but missed the mark on answering our second research question searching for the link between activities in the Makerspace and development of student engineering identities. To narrow down the 17 interviewees to a subset for the focus of this paper, we identified some critical criteria to determine the types of students that could best give us meaningful insight into the impacts of the Makerspace:

- The student identifies and establishes a strong interest in making before coming to college.
- The student personally articulates development in any of the four pillars of engineering identity as a direct result of using the Makerspace.
- The student describes positive improvements in their own performance, competence, and recognition.

These criteria determined we would only be able to focus on three students: Anne, Bob, and Projector Man. These three students were chosen because they all follow a similar pattern that allows for the Makerspace to have significant impact on their undergraduate engineering careers..

We also present a contrasting case of a student who did not come into college with an interest in making, and therefore did not enjoy their time in the Makerspace. Ella preferred written coursework over working on physical projects, so she eventually chose to switch her major from engineering to math. This distinction is important because all four students in this paper hold positive feelings towards math, science, and/or engineering, as seen in Table 1 below. Holding these beliefs helped push her to having a negative engineering identity. Ella is unique in that she articulates the negative impacts the Makerspace had on her engineering performance and self-recognition that eventually caused her to stop pursuing the degree. She is included in this paper to further solidify the conclusions drawn from the other three students.

Table 1: Participants examined in this work, including responses to some of the pre-survey questions.

Pseudonym	Pronouns	Race/ Ethnicity	Family/ Background	Identities	Feelings Towards Math	Feelings Towards Science	Feelings Towards Engineering
Anne	she/her	Hispanic	Lower-middle class, not first-generation	Musician, artists, job outside of school	Positive	Positive	Strong positive
Bob	he/him	White	Lower-middle class, not first-generation	Musician, strong family ties	Strong positive	Strong positive	Strong positive
Projector Man	any	White	Middle class, not first-generation	Athlete, gamer, job outside of school, strong family ties	Somewhat positive	Positive	Strong positive
Ella	she/her	White	Upper- middle class, not first-generation	Musician, job outside of school, strong family ties	Strong positive	Somewhat positive	Somewhat positive

Results

Quotes collected from the students who met the inclusion criteria suggest they all follow the same pipeline where initial interest in making develops students' engineering identities. The first step involves their initial interest in "making" bringing them to the Makerspace in their free time. From there, students' experiences in the Makerspace cause productive development of their engineering identities. Lastly, their experiences in the Makerspace allow them to recognize themselves as engineers based on their own definition of the role of engineers, which were based in making. Our data is broken up into the stages of this pathway that is demonstrated below in Figure 1.

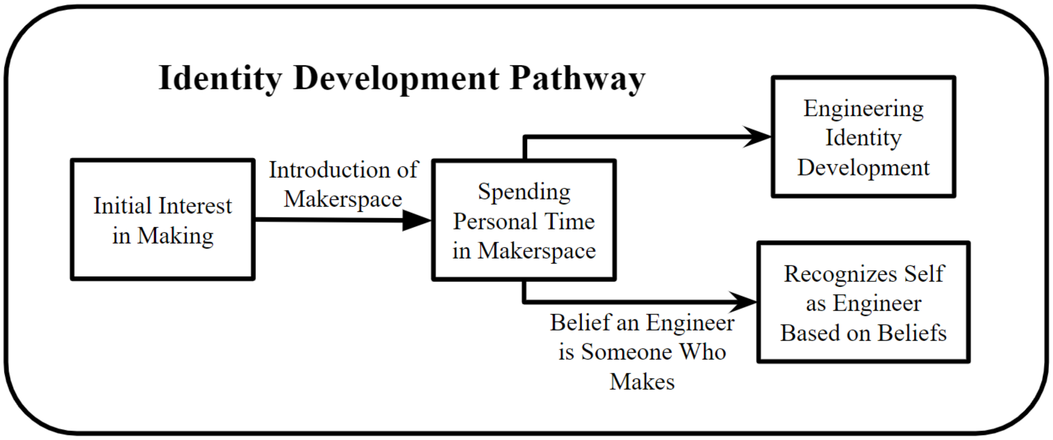

Figure 1. Identity Development Pathway: Pathway that starts with an initial interest in making and leads to engineering identity development.

Arriving to College with an Interest in Making Leads to Using Makerspace to Address Interest

Anne shows a strong interest in engineering-related activities. When asked if she considers being an engineering student a part of her identity she says, "I've always liked to make things, even if they were little kits from the craft store or something." She then connects this background with her experiences at college when she mentions, "so now that I can make those things completely on my own with the Makerspace, it's something that I talk about a lot. So, it's definitely become a part of my identity." Here, Anne clearly articulates that her initial interest in making was further developed through the use of the Makerspace.

Bob came to college with significant experience in making. First, he has close personal connections to woodworking. He says, "And woodworking, I've been practicing in the Makerspace how to use chisels and things like that. I want to get better at woodworking because as I said, my grandpa is a carpenter, and it would be fun to be able to do more of that kind of stuff with him." Bob uses the Makerspace to strengthen his technical skills for an interest he brought to college with him. Likewise, he uses the Makerspace for all his other interests:

> I've always liked working on projects. I do a lot of projects back home. And when I'm in the Makerspace recently, I've been making these little rings out of wood and polishing them and I'm actually starting to sell them. And that's been pretty exciting. I also like 3D [printed] figurines I find on the internet.

Here, Bob emphasizes his excitement about all the projects he's working on in the Makerspace.

Throughout their interviews, Projector Man describes their love of the design process. They say, "I enjoy the design process. I think that's my favorite part of engineering, is designing things," when asked why they like engineering. With this context, they mention:

> I spent a lot of time in the Makerspace working on my freshman project. And on top of that, again, as I mentioned earlier, I like to make things, so I'm typically in there, sometimes late at night, checking on a 3D print or designing something. And hopefully next semester, should my schedule allow, I'll be in the Makerspace mastering the router and wood shop tool specifically.

In this expression, similarly to Bob, Projector Man expresses excitement about their projects in the Makerspace. We see that Projector Man gets to develop their initial interests in making once they come to college and use the Makerspace.

Articulation of Makerspace Impact on Engineering Identity

Something unique to Anne's interviews is the way she describes her performance in the Makerspace. When asked about her favorite part of her classes, she answers:

> [In] the design course, I'd say my favorite part was definitely being introduced to the Makerspace. I was definitely hesitant to use the Makerspace at the beginning, but it's something I'm very comfortable using now and that's definitely my favorite part.

Anne displays performance by describing her confidence in her ability to use the tools in the Makerspace. Anne is proud of what she accomplishes in the Makerspace. This is seen through the fact she tells her friends and family from home all about her time spent in the Makerspace when they ask her about college:

> I know over Thanksgiving break I shared a lot that I was excited to come back here. Definitely say I've been learning a lot and I typically talk about the things I've been doing in the Makerspace or my engineering class because I think that's the most, I don't know, has the most tactile results with things we're making.

In this utterance, Anne shows excitement to her parents about the Makerspace, which can be identified as recognition that the space is meaningful to her college experience.

Bob is frequently in the Makerspace. Because of this, Bob feels like he is a part of the Makerspace friend group. When asked what experience made him feel the strongest positive emotions:

> Honestly, sitting in the workshop and working with friends and also just chatting with a bunch of the engineers, and also a couple non-engineers go up there to work on projects and it's fun to make things and talk with friends and look at each other's cool projects and just kind of be there for each other.

Others are accepting of Bob as a part of the group which can be considered recognition by peers.

In the same way that Anne experiences recognition by talking about her involvement in the Makerspace, Projector Man does too. They said:

> Whenever I'm meeting someone, I start up by telling them that I'm an engineering and physics double major. And then depending on how long we have, and if it's something more formal, then I'll go into some of my hobbies and my passions at school. But if it's not, I'll just leave it there and say I enjoy problem solving, get a very, very fast introduction. But if it's longer, then I'll speak more to… I was speaking to someone in our Makerspace, and in that case, I spoke more about some of the projects that I had planned on working on and some things I intended on doing in engineering.

In this description, Projector Man shares their love of and interest in making with an audience that they know will respect, understand, and appreciate it. Projector Man also displays performance when talking about their accomplishments in the Makerspace:

> I think my biggest success is kind of a small thing, but I think it was that during finals week, I was able to take some time out and sit down and design a gift for a friend and then go into the Maker Space and make it, because to me, I could say, "Oh, my

> engineering project," but that was very guided, whereas for this, it was completely unguided. I sat down and I said, "Okay, I need to make this thing for this person. Let me sit down and design it." So I considered, "Okay, what material do I want to make it out of?" I was like, "Okay, how big do I want to make it?" And I designed it and I made it, and that was kind of the accumulation of all of my engineering skills and I felt really, really good as a result.

Here, Projector Man shows competence through their thoughtfulness when designing the product and performance for successfully making something in the Makerspace.

Student Recognizes Self as Engineer Based on Beliefs of an Engineer's Role

All three of these students were asked to define what they believe to be the role of an engineer. With each of their beliefs assigning engineers to hold the role of at least one of the facets of making, they recognize themselves as being capable of that job.

When asked to describe an engineer, Anne says, "I'd say it is a professional who comes up with solutions to people's problems." Anne's ability to solve problems while designing her project manifests as recognition of herself as an engineer. When asked if she experienced anything that made her feel like an engineer during the semester:

> I would say a lot of times just during the design class, I felt working with other people to solve problems, especially since we did that. The final catapult design, that was the problem we had to face or any parts of the catapult that weren't working. We had to look at it together and compile different tests or different ideas to fix that problem.

From this description, it is clear that solving problems through successfully building something with a team allows Anne to feel like an engineer.

When asked what experience made him feel like an engineer, Bob says:

> I guess I felt most like an engineer during the Chem-E-Car [the second semester design project] when I was just designing and redesigning and redesigning and making all these drawings, talking with my group about ideas, trying to organize them and convey them well.

He believes an engineer is "someone who fixes stuff that doesn't work or makes something more efficient or makes something more safe." Bob describes that he feels like an engineer while making based on his own definition of what an engineer does.

When asked to describe an engineer, Projector Man says, "Generally, whenever I think of an engineer, I think of someone who is very fluid at problem solving." With this value of problem solving, their answer to a question regarding any moments that made them feel like an engineer shows that skills utilized in the Makerspace are correlated with their ability to see themself as an engineer. When talking about their job with the theater department, they say:

> We needed to hang a projector to show some images for a show. And even then… I had a design and he kind of reminded me that sometimes simpler is better. So, even so I'm still learning. But this semester I think has been full of small moments that kind of have helped me feel like an engineer and have helped me improve as an engineer.

With problem solving being a component of making, Projector Man feels that making makes them a better engineer.

Contrasting Narrative

Next, we look at the case of Ella, a student who does not come into college with an interest in making. When asked about her relationship with engineering during her first interview, she says, “I would say maybe neutral at the moment just because I haven’t done any engineering stuff until this semester, so not negative though.” So, with little experience with engineering, she’s allowing college to form her opinions on engineering. During her second interview, she explains why she’s decided to not continue with the engineering curriculum and says, “I have taken [two semesters of engineering design] and I didn’t enjoy those courses. I don’t like design. The things that I did like about those courses were not the design parts. It was more about doing the Fusion 360 or doing lab in Excel,” and, “Yeah. I don’t like the Makerspace or anything like that. I am switching to computer science and a math minor because I really like math.” Here, Ella much prefers written coursework over open-ended design projects. Without coming into college with a passion for making, it doesn’t seem as though she could warm up to the Makerspace.

This had negative impacts on her engineering competence. When asked if she feels like she belongs in engineering, she agrees:

> In some ways I do belong. However, when I’m in the Makerspace, working on the design projects and just working with my design group, I feel almost as if I don’t belong, or I see my other group mates and I can tell they enjoy it and I can see that they’re really good at it. I think that’s great for them. But then I feel like on the flip side of that, I’m sort of like, ‘Yes. I know this is not for me or this part of engineering is not for me.’

In this utterance, Ella opposes our definition of competence because she doesn’t see herself as good at designing when comparing herself to her peers. She also opposes Godwin’s [11] definition of interest as she does not have positive feelings while designing. Because she cannot see herself relating to her peers that enjoy design, we can also claim that she experiences a lack of self-recognition in engineering. These feelings remain consistent during her exit interview right before starting the next semester as a computer science major. When asked if she is a part of the Makerspace group, she says she is not:

> I think it’s partly the friend group, but also I think that the people in the friend group like the Makerspace. And I think they feel comfortable there in the Makerspace and they like using the tools there. And so aside from the fact they’re not my best friends, I don’t relate to them in that I don’t feel comfortable in the Makerspace. I don’t really want to be there if I don’t have to be there.

Here, Ella reiterates that she doesn't like making or using tools to build things, which in her eyes disqualifies her from being an engineer. Without that recognition of herself, she ultimately switches majors to computer science which requires the kind of work she is more comfortable with.

Discussion

After the analysis of each of these student’s evidence, it is clear Anne, Bob, and Projector Man follow similar pathways from their initial engineering interests that eventually develop into their ability to recognize themselves as engineers through the Makerspace’s impacts on the development of the four pillars (performance, competence, recognition, and interest) of their engineering identities. To solidify this claim, we see a lack of interest in making causing the Makerspace to be a hindrance to Ella's engineering identity development.

Referring back to our pathway from Figure 1, The first step is that these three students come to this school with an already well-established engineering interest in making. Looking at these students' beliefs of what an engineer does, we can make the claim that these students choose engineering because they already like to do what they think engineers do for a career. Anne, Bob, and Projector Man all believe that in essence, engineers are problem solvers. When asked interest prompts in the interviews such as, "Tell me about why you pursued engineering coursework this semester," and, "What do you like about your engineering class this semester," all three of their answers tie back to the problem solving process. With the belief that an engineer is someone who problem solves combined with an initial interest in making, each of these students is able to reflect on their experiences and recognize themselves as engineers within their own definitions (RQ1).

Now, we move forward along the path. They've found the Makerspace and are excited to utilize the tools. Each of the three of them make it a point to mention the positive emotions surrounding accomplishment in the Makerspace. Projector Man pins a lot of success to their creations in the Makerspace. Bob is excited that he can continue his personal woodworking projects there. Anne is excited because she feels she is learning from the people in the space. All three of these students display strong examples of engineering performance and competence in the Makerspace through their confidence in their creations. This excitement about accomplishments in the Makerspace allows for their initial interests to persist and develop as they continue using the space for both class-related and personal projects.

The Makerspace also influences each of their nuanced recognitions. Bob experiences recognition through working with others. Anne and Projector Man experience self-recognition when they use the Makerspace as a talking point about their engineering accomplishments. Not only are these students learning and growing, but they can reflect and tell others about all of the learning they are doing. So, the following connection exists: students who come into college with an established interest in making are able to recognize themselves as successful at engineering when they accomplish something in the Makerspace (RQ2).

Ella provides a different perspective to the Makerspace's effect on engineering identity because not only does she articulate how it hurts components of her engineering identity, but she also identifies that it seems to be positive for people who have an interest in making. With this articulation, it is clear the Makerspace impacts the identity development of students in engineering who come into college with intentions of expressing their interests in making by allowing for the development of their engineering identities within the space.

Conclusion/Future Directions

Even though both research questions were addressed and answered separately, it is important to note how much the two conclusions overlap. On a broader scale, we can see the connection from initial interest in making, especially problem solving, to a recognition of self as an engineering individual when taking into consideration each student's own personal belief of what a professional engineer does. However, this leap is heavily influenced by the availability and accessibility of the Makerspace for students who choose engineering from their attraction to making. The Makerspace provides a unique opportunity for students with significant interest to spend their free time working on personal projects. This is when a lot of the building of competence, performance, and recognition takes place as they successfully create while also sharing their products with like minded individuals. These benefits to the development of engineering identity for this specific subset of students directly correlate with their retention in engineering programs. Having makerspaces available to students will increase the retention of engineering students who come into the program with an initial interest in making. Makerspaces serve as a solution for the current demand for intervention methods in first-year curriculum that will increase retention rates within engineering programs.

Future studies should increase the diversity of study contexts. This particular university has a significantly small engineering cohort size. Knowing that each makerspace is different [2] and that the students who frequent the space are impactful on creating the atmosphere [7], such a small cohort size may make it easier for the students to create such a sense of community in the space. Larger cohort sizes may impose different challenges to accessibility, which may in turn change the effectiveness of influence makerspaces have on the development of engineering identities. It is important to ask these same questions as we have in this paper to all kinds of makerspaces in order to explore optimal configurations for identity development and retention.

Future studies should look into different contexts of student beliefs. This paper focuses on four students who all have positive feelings towards math, science, and/or engineering and believe that an engineer is someone who "makes." With that in mind, our conclusions and discussions represent a niche subset of engineering students. Tracking engineering identity within makerspaces of students who have negative feelings about engineering or have a different definition for the stereotypical engineer may lead to different discoveries.

Likewise, future studies should explore the role that sense of belonging plays on retention within the scope of the Makerspace. Our interview protocol currently limits us to identity exploration and analysis. With an adjusted protocol, researchers should explore the relationship between identity development, community building, and feelings of belonging as results of campus makerspaces.

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