

Board 214: An Investigation of Women Engineering Undergraduate Student Belonging in an Academic Makerspace

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Abstract

Academic makerspaces are physical locations that help support engineering classroom instruction and provide exposure to workplace skills like prototyping and design. Makerspace proponents have championed equitable makerspaces as sites for increased access to tools and knowledge in science and engineering [1]. However, this promise is yet to be realized, with an emerging body of work critiquing the notion they are delivering equitable benefits to all students [2]–[4]. This literature finds that access is not sufficient for true democratization, which cannot be reached without the full participation of a diverse student population. Hagerty et al. [5], define full participation as characterized by individuals' sense of belonging in these spaces.

To further the discussion on equitable makerspaces, this study focuses on understanding the sense of belonging of women engineering students in academic makerspaces. Although prior work has explored makerspace users' sense of belonging, these studies are typically quantitative, not answering how students understand their belonging [6], [7]. Qualitative work on topics similar to sense of belonging, like the culture of belonging within makerspaces, is often centered on the staff or administrator perspective [8]. There is limited work addressing the factors impacting students' sense of belonging from their point of view. To fill this gap, we interviewed four women engineering students that were involved in different makerspaces at a large public, research-intensive university in the Midwest. Specifically, our work seeks to understand the impact of previous making experiences on students' belonging. The work of Hagerty et al. [5] was used as a theoretical framework to inform the interview protocol and data analysis.

Results from this analysis show that the factors signaling belonging changed as women increased their level of making experience, either prior to entering the space or during their time in the makerspace. Students with little prior experience saw their belonging as a function of the amount of time they spent in the space, while more experienced participants tied their belonging to social aspects or to the purpose of the space. The findings from this study provide an interesting point of reflection for makerspace staff to consider when creating a makerspace that encourages belonging. To promote a culture of belonging in academic makerspaces, this study suggests administrators and staff members should consider the variation in understanding how one belongs to a space.

1 Introduction

Academic makerspaces are spaces where users learn, share, and create new knowledge through the act of building physical objects using tools and supported by expertise from mentors or staff members [6], [8], [9]. Building equitable makerspaces is a major goal for many makerspace

proponents in order to increase access to knowledge that was once out of reach for many [10]. Prior research has shown that access to tools and expertise in makerspaces can improve students' engineering identity, self-efficacy, and sense of belonging, leading to higher retention in the engineering field [6], [8], [9], [11]. However, an emerging literature questions whether these spaces are truly equitable and democratic, finding that inequalities and barriers are still present which can exclude some groups of students [2]–[4]. This research suggests it is challenging to ensure all students, especially traditionally marginalized students, can fully participate in makerspaces.

There is a growing body of work examining strategies for creating an equitable academic makerspace. Many of these approaches have focused on increasing access [12]–[14]. In these papers, improved access increases the diversity of users of the space. Other researchers have suggested that this may not be sufficient to achieve a truly equitable makerspace [4]. They have found benefits from the affordances of the space are not realized until students reach a level of full participation [15]. Hagerty et al [5], characterize full participation in a community through a student's sense of belonging. Thus, in order to create equitable makerspaces with full participation of a diverse set of students, we must examine factors affecting the sense of belonging for marginalized students. As an initial effort, this study focuses on the sense of belonging for women students in academic makerspaces.

2 Background

This study draws on prior engineering education research on equitable academic makerspaces and sense of belonging as a theoretical foundation.

2.1 Sense of Belonging

In mental health research, sense of belonging is a form of connection to one's surroundings, either people, places, or things [5], [16]. A student's sense of belonging is critical to their full involvement in the makerspace environment, as well as their attribution of how meaningful it is to be involved [5]. In academic makerspace literature, belonging is often defined in terms of the connection, acceptance, or sense of fit of an individual to the others in a group [6]–[8]. However, in the work of Hagerty et al. [5], an additional attribute of sense of belonging is considered. This study used the framework of Hagerty et al. [5] as a lens to understand sense of belonging. In this framework the two defining attributes of sense of belonging are: 1) a person's experiences being valued, needed, or seen as important in regards to the experiences of others; and 2) a person's fit to others through shared or complementary characteristics. The consequences from sense of belonging are: 1) psychological, social, and physical involvement; 2) attribution of meaningfulness to being involved; and 3) the creation of a foundation for emotional and behavioral responses [5]. For Hagerty et al. [5], sense of belonging is understood as "the experience of personal involvement in a system or environment so that the person feels

themselves to be an *integral* part of that system or environment.” This framework informed the development of the interview protocol, data analysis, and interpretation of the findings.

2.2 Makerspace culture

Research suggests that the culture of a makerspace has a significant effect on the sense of belonging of students [8]. Based on Godfrey’s theoretical model for engineering education culture, there are multiple levels of the manifestations of culture: observable and tangible manifestations (like artifacts), shared and understood cultural values or norms, and unconsciously held beliefs and assumptions [17]. Alongside the cultural components of the makerspace, the physical and structural aspects all together work as ambient belonging cues which communicate the “type” of individual that belongs in the makerspace [18]. Typically, parts of engineering culture, which is traditionally male-centered, are reproduced in academic makerspaces [4], [6]. This closed-loop culture, from engineering, reinforces a “hegemonic, majority population and culture” which signals to students that are not a part of the majority population that they do not belong [8]. To create an equitable environment that encourages all students to belong, Villanueva Alarcón et al. [8] assert that a culture of belonging, or a ‘boundary crossing’ culture, must be purposefully created using a reflexive, deep approach. The literature on makerspace and engineering culture was used in this study to develop the interview protocol and to interpret the findings.

2.3 Women in makerspaces

Researchers have previously explored women’s experiences within the academic makerspace environment. Roldan et al. [19] conducted a qualitative study to understand engineering undergraduate female students’ senses of community and belonging within the makerspace environment. Using the work of McMillan and Chavis [20], Roldan et al. [19] focused on women’s sense of community which encompassed the attribute of membership, related to sense of belonging. It was found that women were impacted by the presence of physical indicators that they are valued in the space. Approachability and willingness to support students were also shown to be important to encourage women’s sense of community in the space. Tomko et al. [21] conducted a study to understand the pathways into the makerspace for women, to highlight the barriers to participation. The authors found that the women’s pathways had the following major aspects: 1) exposure to early forms of apprenticeship, 2) experiences overcoming the limiting gendered expectations imposed upon them by other makerspace members, 3) successful transitions in the academic makerspace that related the work to members’ passions and coursework, 4) relationships that helped members reach fuller participation through expanded access, leadership, and visibility. Both of these studies conducted interviews with female engineering students to understand their lived experiences, which guided the methodology of this study in terms of conducting semi-structured interviews to capture women’s sense of belonging.

2.4 Research Gap

The work of Villanueva Alarcón et al. [8] and Roldan et al. [19], helped create a base for this study to continue exploring women's sense of belonging in the academic makerspace environment. This study seeks to expand our understanding of women makers with different levels of making experience and what they attribute as meaningful to their sense of belonging. To further understand the nuances of sense of belonging in makerspaces for women, this study sought to answer the following question:

RQ1: How does level of experience with making impact these women's sense of belonging?

In this paper, we explore this question by interviewing 4 women engineering students on their lived experiences engaging with different makerspaces at the same academic institution, all with varying degrees of previous making experience. This work can be used by administrators and staff members to reflect on the ways in which women students interpret their sense of belonging to create interventions that create a culture of belonging.

3 Methods

Previous literature on academic makerspaces have pointed to the importance of a sense of belonging for students to fully participate in an academic makerspace [8], [15], [19]. To investigate women undergraduate engineering students' sense of belonging in makerspace environments, we employed a thematic analysis of multiple interviews. This study is part of a larger study that is focused on understanding factors that impacted students' sense of belonging, specifically minoritized students. The interview approach allowed us to collect rich information about each of the participants' experiences in makerspaces and their perceived belonging. This study specifically focused on the experiences of four women, with varying levels of making experience and use of different makerspaces at their common academic institution.

3.1 Data sources

Participants

The study reported here includes interviews with 4 women makers in an undergraduate engineering context, selected from a larger data set of interview participants because they all had varying degrees of makerspace experience and were engaged in makerspaces at the academic institution. The participants self-identified as people who had worked on a project in a makerspace at the university (either for a curricular project, co-curricular project, or personal project). Three of the women were mechanical engineering majors and one of the participants was an environmental engineering major. Two participants had no experience making, having not seen a makerspace or the tools before. One participant was characterized as having some

prior experience, as they were introduced to making by their father who worked in construction. And one participant had significant experience as an avid maker that took woodworking and metal working courses in high school and was involved as a staff member in one of the makerspaces. Two of the participants were members of a co-curricular team and one participant was making only for a specific class project. Participant demographics are included in Table 1.

The participants of this study were recruited from convenience sampling, where staff members and co-curricular team leaders were asked to advertise a study on understanding students' perspectives of their makerspace experiences. Email, word of mouth, and outreach to student groups like Society of Women Engineers and Society of Hispanic Professional Engineers were used to recruit students. To narrow down the participant pool, a demographic survey was sent to all of the interested participants. This study then focused on bounding the data sources to students that are underrepresented in the mainstream makerspace population (e.g., women, racial/ethnic minorities, members of the LGBTQ+ community).

Table 1: Participant Demographics

Pseudonyms	Engineering Discipline	Prior Making Experience	Undergraduate Makerspace Experience	Makerspaces Used
Katherine	Mechanical Engineering	None	~ 4 months	Major specific machine shop
Sarah	Mechanical Engineering	None	3 years	Student team makerspace
Valerie	Environmental Engineering	Taught making skills by father	2 years	Student Team makerspace, Makerspace for social impact projects
Talia	Mechanical Engineering	Took a metal working course in high school	3 years	Major specific machine shop, Makerspace for social impact projects, 3D printing lab, Small student led makerspace

University and Makerspace Context

This study was conducted in a large public, research-intensive university in the Midwest. The making culture within this academic institution is still growing. The majority of students; making opportunities were through curricular and co-curricular activities. At the time of the study,

students working on personal projects was uncommon at this institution. The makerspaces in which participants engaged included: a student team makerspace, a major specific (mechanical engineering) machine shop, a small student-led makerspace, a 3D printing lab, and a makerspace for social impact projects. The student team makerspace allowed all students of the university access to the space as long as they are a part of one of the formalized co-curricular teams of the university. The small student-led makerspace permitted a small group of students, that lived in the building (typically engineering and art majors) where the makerspace is located, use of the space. The mechanical engineering machine shop was used only by mechanical engineering majors that engaged in curricular making projects. The 3D printing lab allowed access to all university students and was housed in the basement of one of the buildings in the engineering/arts campus of the university. The makerspace for social impact projects was open to all students at the university and functioned as a student team makerspace that allows students to engage in personal making projects and co-curricular making projects focused on social impact.

3.2 Data collection

Data were collected via semi-structured interviews to allow us to gather in-depth information about participants' lived experiences and their perceptions of their sense of belonging. Academic makerspace literature on belonging, specifically culture of belonging, served as an example of a qualitative methods framework that guided the questions added to the interview protocol (Villanueva Alarcón et al. 2021). In the interview protocol, we included questions about the makerspaces in which they worked, their impressions of all of the makerspaces on campus, and their experiences of belonging (or not) in the makerspaces. All of the interviews were conducted remotely online using Zoom and were recorded. Interviews lasted approximately an hour.

3.3 Data analysis

Data were first transcribed from the recordings. Then interviews were read in their entirety to get a sense for what participants said. Next, the data were analyzed in three rounds of coding. General codes were used to describe sense of belonging, using In-Vivo coding to keep the data rooted in the participant's language. In the second round of coding, the codes were clustered to create broader themes related to sense of belonging and the factors that impacted belonging. Some examples of these themes were the following: time spent, space, intimidation, and interactions. The final round of coding was conducted to identify how aspects of sense of belonging in our inductive coding aligned with the framework created by Hagerty et al. [5]. For example, the interactions in the space that were seen to have a positive impact on the student's sense of belonging aligned with the attribute of having their experience being valued and needed in the makerspace environment in regards to the experiences of other members.

4 Findings

We identified three factors that impacted the way in which the women of this study perceived their sense of belonging to their academic makerspaces: 1) time spent in the makerspace, 2) social aspects/interactions that occur in the makerspace, 3) motivation behind using the makerspace. The most salient finding was the impact of level of making experience, which incorporated their prior experience, on the engineering students' perceptions of their senses of belonging.

Sense of Belonging Continuum

The perceived sense of belonging of women engineering students was different depending on their level of experience in the makerspace. The woman with the least makerspace experience, came in with no prior experience and spent around 4 months' time in the space, attributed her sense of belonging solely to the amount of time spent in the makerspace. Another woman, that came in with no prior making experience but spent 3 years as an active member of the makerspace, tied her sense of belonging to her time spent in the makerspace along with the social connections/status she had made/reached. Similar to this, the woman that came in with some prior making experience and exposure from a parental figure attributed their sense of belonging to the social aspects of the makerspace. Finally, the woman with most making experience tied their sense of belonging to the makerspace in terms of their enjoyment of making and building. The sense of belonging continuum is depicted in the following figure.

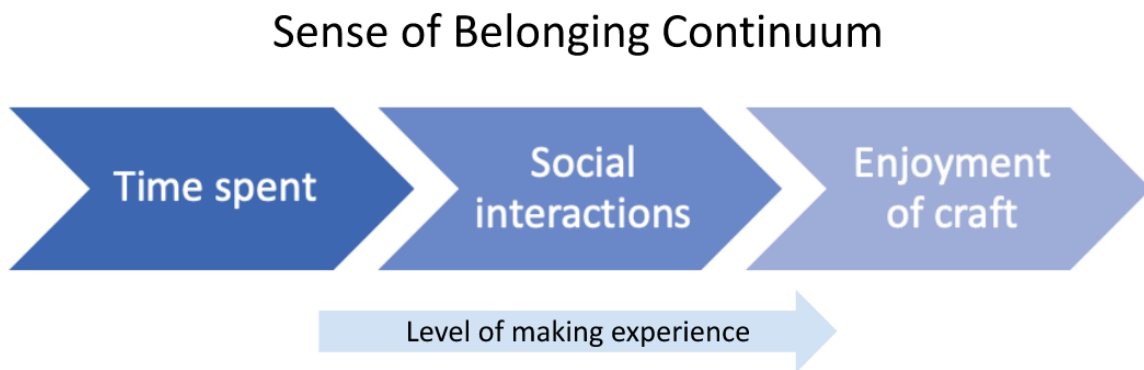


Fig 1. Sense of belonging continuum

Time spent in the makerspace

The amount of time spent in the makerspace, either working or just being in the space, was used as a marker for women engineering students' sense of belonging, specifically for the two participants that had no prior experience in making. More time spent in the makerspace was equated to an increased level of knowledge for undergraduate students. Having a better understanding of the makerspace, including the tools, protocols, procedures, rules, and norms, was seen to make those with no prior experience more comfortable and confident navigating the space.

For instance, Katherine, a mechanical engineering student with no prior experience in making, described that throughout the semester, her confidence and knowledge of starting up the machines and navigating the makerspace increased the more often she spent time in the major-specific machine shop. She was taking a required course for her major that involved using the machine shop to create a curricular project. The time she spent in the makerspace, which she perceived as a lot, gave her the confidence to know how to move in the makerspace (who to ask questions and the overall procedure) which made her feel like she was a part of the machine shop;

“I spent a lot of time in there. So, then I got used to just going in there and starting things. I remembered how to start machines on my own, how to start the basic stuff because I was going there almost every day, I think, with my team and by myself....I feel like if I were to walk in there again I wouldn't feel as new. I make it sound like I spent years in there, but it just felt like I spent a lot of time in there where I know who to ask ... I know who to ask questions to now. I know what the procedure is. So yeah, I do feel more a part of the machine shop now if I were to walk back in there.”

Katherine also described an experience where she felt like she did not belong in the makerspace. She engaged in comparison over her making abilities to the other users of the makerspace which made her feel even worse, she explained. Her lack of prior experience made her feel like she was unprepared or behind from her peers, but overtime she began building up the knowledge of how to use the machines correctly and felt less out of place.

“There was a day, it was just a really hard day in general, that I went in there and I just wasn't doing anything right. It was during that time where more people were going in there, so it was starting to get more loud in there. Chances of someone getting hurt because there wasn't someone supervising them all the time were higher. I didn't get yelled at, but I just don't handle authority telling me that I did something wrong very well. But it was for my own good because I wasn't doing things right. That mentality of this is my fault, and comparing myself to other people who were just so good at what they were doing, made me feel a little bit like I didn't belong there.”

Spending more time in the makerspace, and having more exposure to the way the makerspace functions and the craft of making add to the participant's feelings of belonging. This is exemplified by the words of Sarah, a member of a co-curricular team that works in the student team makerspace. She walked into the makerspace her freshman year with no knowledge of making, not having known what a mill or lathe was. For 3 years, she has participated in her co-curricular team and is currently spending around 40 hours a week in the student team makerspace. To feel like a part of the makerspace, to belong in the makerspace, Sarah felt like it was really important to have some knowledge of the space. In the second quote, she ascribed

increased knowledge of the makerspace to the amount of time spent by each co-curricular team in the shop; she stated that the teams that were not in the space as often do not have the same amount of knowledge as other teams with a larger presence in the space.

“I think also just having a knowledge of the space is really important to making it feel like comfortable and making it feel like I'm part of the space is I know what's going on.”

“I think it's really the amount of work that you do in the shop and the amount of time that your team is present, which feels like a bigger presence in the shop is maybe a better way to say it. But teams with smaller presences don't really, I feel know the shop as well, or know the staff as well, or know anything as well as people who are there all day every day, like a lot of people on bigger teams are.”

The amount of time spent and work done in the shop was equated to a bigger presence in the shop. The presence or time spent in the makerspace was then related to how well the members of the team know the staff or *anything* in comparison to other teams.

Social aspects of the makerspace

One of the other ways in which the women undergraduate students perceived their belonging to the space was in relation to the social interactions that they had experienced in the makerspace environment. The treatment given to the participants either encouraged their participation and belonging to the space, or deterred them from belonging and possibly lead to them leaving the makerspace. As the second stage of the continuum, this relation between the social aspects of the makerspace and sense of belonging was seen in women that had an intermediate level of making experience.

Sarah is considered to be a participant that moves across the continuum. She started with no prior experience in the makerspace, similar to Katherine, but she acquired more making experience over the 3 years spent working in the student team makerspace for her co-curricular team. In comparison to Katherine, who only spent 1 semester working in the major-specific machine shop, Sarah considered the social aspects of the makerspace when evaluating her sense of belonging. Sarah considers herself to be a big part of the makerspace as she spends a lot of time there to work or hang out with other makerspace members. She also mentions that during her time spent in the makerspace, she learned how to weld and is now able to teach others how to weld.

“I think I make myself a pretty big part of the [student team makerspace]. I think that I'm there, obviously a lot of time in the week and I just go and hang out and do homework or spend time messing around. But as I mentioned, I'm a welding trainer now and I'm supposed to be on staff

next year. So I feel like most people know my name, most people know my deal and understand what's going on, so.”

The mention of being known and other people in the makerspace *knowing her deal* indicates a move across the continuum, where belonging is starting to be tied to the social aspects of the makerspace along with the time spent in the space. Spending time messing around and building relationships with team members and other makerspace users makes women undergraduate students feel like they belong in the space.

Valerie was also engaged in a co-curricular team and she described her sense of belonging as influenced by social and cultural aspects of the makerspace. She had previous experience in making because her father, who worked in construction, taught her how to build and use specific tools. She engaged in two of the makerspaces on campus, the student team makerspace and the makerspace for social impact projects. During her interview, she compared the culture and social aspects of the two makerspaces. When describing her perception of the student team makerspace, she described the members of the makerspace as “intense” in terms of spending all hours of the night in the space and their behavior towards their tools and space. To further explain the intensity of members in the makerspace, she stated:

“I just know that like when like you went in there like it always felt like there were like people using their tools and like I know when people like discuss it it's like ‘Oh, this is our space that people want to borrow our tools and I'm just like I don't know it, it didn't seem like a welcoming environment if you weren't in a project team you're not even allowed to use it really if its- if you're not using a project team”

Valerie described the makerspace as not a welcoming environment because of the ways that members of the space behaved and treated others. Ultimately, Valerie did not continue engaging in the student team makerspace and instead began participating in the makerspace for social impact projects. She made the following comparison between the two makerspaces:

“Like it didn't felt, I didn't feel like you needed to like have, to like stake your claim to like be in there. It felt like you could just be in there”

Valerie felt she was allowed to be in the makerspace for social impact projects, which was different from her feeling in the student team makerspace. Valerie mentioned that there was never a time when she did not feel welcomed in the social impact project makerspace. When asked to describe a time when she felt like she belonged in the makerspace, Valerie recounted an interaction with one of the staff members:

“Thinking back to like when we wanted to 3D print something, the 3D printers hadn't been used in like a while and I was like working on it, and like they weren't really working and then like I made a time with the lab tech to like work on it together, and we were like, we sat there with next to two 3D printer and we both tried to like fix them and work together on them, like collaborating on trying to figure out how they worked. ... it kind of felt like we were on like the same standing, like we were both like trying to figure it out, it wasn't like like, like they were like the expert but they were also like trying to figure it out too.”

Collaborating with the lab technician, who was a woman studying engineering as a graduate student, was a positive experience for Valerie. She felt like she was in the *same standing* as the staff member, making her feel recognized for her knowledge and experience. Social interactions like this one, which show respect and value to the participant, are positive experiences that highlights the welcoming environment of the makerspace and makes women feel like they belong.

Motivation of Making

Talia was the most experienced maker of all the participants. Talia was involved in 4 makerspaces on campus: the major specific machine shop, the student-led makerspace, the university-wide makerspace, and the 3D printing lab. During the interview, Talia remarked that she belonged in all of the spaces that she participated in.

“I feel like even though I struggle with some of them more than others, or there are some places where I feel more welcomed and taken seriously than others, I feel like I belong in all of them.”

Talia acknowledged that some places were not as welcoming, and the social interactions that occurred in the space could impact how easily one was able to belong the makerspace. She related her belonging not to the social interactions of the space, but rather her own motivation for using the makerspace:

“The fact that all of those spaces, the things that I am doing there are the things that I want to do and that I've always enjoyed doing. And regardless of what someone else's opinion is of whether I should be in that space or not, I'm there to do the things that I want to do and that those spaces are meant for.”

She used the makerspace for what it's *meant for*, which is to make and create things. She found enjoyment in the craft and art of making and therefore the opinions of others, and the social and cultural aspects of the space, did not impact her belonging. She felt her sense of belonging came from within.

5 Discussion

This study revealed that women makerspace users, with varying levels of making experience, evaluate their belonging differently. Women with lower levels of making experience typically associate their belonging with the amount of time they spent in the makerspace environment. As the level of making experience increases, the women's sense of belonging shifts towards being related to the social relations that occur within the space. When the woman views themselves as a "maker" their belonging is no longer in the hands of anyone other than herself. She feels as though she belongs in the space because she is performing the practices the space was designed for. In the following paragraphs, the sense of belonging framework by Hagerty et al. [5] will be used as a lens to understand the nuances of belonging that the women students described.

From this study it was found that the women with lowest levels of making experience associated their belonging to the amount of time they spent in the makerspace environment. More time in the makerspace was related to improved confidence and increased knowledge about the makerspace, the procedures, and the staff members of the space. From the sense of belonging framework by Hagerty et al. [5], time spent in the makerspace could be considered a way students evaluate their fit in comparison to the rest of the group of users. In the case of Katherine, she explicitly mentioned comparing herself, in terms of her level of prior experience and her time spent in the space, in relation to her peers that were also using the makerspace. She felt as though she needed to spend even more time in the makerspace in order to meet the level of knowledge and confidence her peers had, in order to fit in. Similarly, Roldan et al. [19] linked belonging, or membership, to the common characteristics shared between makerspace users like their type of expertise, which is what Katherine was trying to build by spending time in the space.

When explaining her sense of belonging to the student team makerspace, Sarah pointed to the 40 hours a week she spent in the makerspace working and connecting with other users. She also mentioned that the members that do not spend as much time in the makerspace are not given as much respect, which implies that "fit" is associated with the amount of time spent in the makerspace. Perceived effort and commitment indicated by the amount of time spent in the space, which implies that value and importance were placed on the time spent in the makerspace by the group of users. Therefore, a makerspace user that spends more time in the space may feel more valued, respected, and accepted by their peers because of their commitment to being in makerspace. This relates to both attributes of belonging, where the individual feels valued and has a common characteristic with their peers [5].

The participants that were characterized as having an intermediate level of makerspace experience associated their sense of belonging with the social aspects of the makerspace. This follows the work of Nadelson et al. [22] that linked students' sense of belonging with the influence of social interactions. When Valerie described her makerspace experiences, she

contrasted the “intense” student team makerspace with the welcoming environment of the makerspace for social impact projects. One of the notable differences that Valerie mentioned about the two makerspaces was the two women lab managers in the makerspace for social impact projects. During her interview, she went on to speak about the gendered assumptions about making and how that felt more present in the space if all of the supervisors of the makerspace were men. These insights are similar to the findings of the study conducted by Roldan et al. [19] which pointed to the importance of having women as leaders in the makerspace environment. Research has shown that having women as role models in the space have been found to balance out the negative experience of working in male-dominated environments [19].

Although makerspaces are open for women to participate, research has shown that it is important for makerspaces to have indicators of women being valued in the makerspace environment [19]. The presence of women role models and physical indicators, like hair ties and smocks, communicates to women users that they are valued and seen as important in the makerspace. The intentional choice to represent women as leaders in the makerspace environment reflects the underlying values of the makerspace. Research suggests that uncritically developing academic makerspaces could reproduce the heteronormative, white-male focused culture present in engineering contexts [4]. These makerspaces can thereby reflect and promote values that do not align with the women that want to participate in these spaces [4], [8], [19], [23], [24]. Valerie mentioned how she felt like she was on the same standing as the women staff members, where they valued her expertise in making. Feeling as though one’s knowledge is valued and that they are on the same level, in terms of power, as the staff members implies that the student user is a valued member of the makerspace community and that their knowledge and skills they bring to the space are seen as important.

Talia, the participant with the most making experience, associated her sense of belonging with the purpose of the makerspace. Rather than evaluating her belonging based on the social interactions in the space or the time spent in the makerspace, she felt like she belonged because she participated in the activity the space was *meant* for. This participant did not connect her making activities to the other individuals participating in making, but instead tied her making with the function of the makerspace. Talia formed a connection to her surroundings, specifically the values and mission of the place she did making in. Similar to the second attribute of belonging by Hagerty et al. [5], Talia “fits” in the makerspace environment because of the common making practices that are supposed to occur in the space. The sense of belonging framework could be expanded to reconceptualize “fit” in terms of the function of the makerspace, along with the typical form of analyzing fit in relation to a group of people.

6 Conclusion and Future Work

In conclusion, this work examined the experiences of four undergraduate women in makerspaces to understand how they evaluated their sense of belonging. Limited work has been done to understand the factors that influence the sense of belonging of women in academic makerspaces, with none specifically looking at the differences across the level of making experience. Semi-structured interviews with the four subjects were transcribed and then analyzed to generate findings on the factors they related to their sense of belonging. Results from the multiple rounds of coding and analysis were used to answer the following research question.

RQ1: How does level of experience with making impact women's sense of belonging?

The women of this study understood their sense of belonging, in terms of perceived, fit, value, importance, and need, differently depending on their level of makerspace experience. Makerspace experience, for this study, was regarded as the level of prior experience before entering a makerspace and the amount of experience engaged in a makerspace. For the two participants that came into their makerspace experience with no prior knowledge in making, they related their fit to the local maker community by the amount of time they spent in the makerspace. Moving across the continuum, the participants that had an intermediate level of making experience (Sarah and Valerie) characterized their belonging to the space in terms of their perceived value, importance, and need, which was understood based off the social interactions that occurred in the makerspace. Lastly, the participant with the most makerspace experience related her sense of belonging to her fit with the purpose of the makerspace.

This presented study is not without its limitations. First, the convenience sampling approach was chosen for this study because of the ability to easily access participants for the study. The small sample size limited the generalizability of the findings for this work. The sample size, however, allowed us to dive deeper into the lived experiences of the participants to understand their sense of belonging. In future work, we plan to continue understanding the sense of belonging of women and other minoritized students in the academic makerspace environment with a larger sample size. We hope, in future work, to create interventions that create a culture that encourages student belonging in the makerspace environment.

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