Student Staff in a University STEM Makerspace Reason for Entering Makerspace—Past, Present, and Future

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Student Staff Reason for Using a University Makerspace

Abstract

The purpose of this research paper is to investigate the experiences and interactions of student staff in university makerspaces. Student-run university makerspaces are uniquely primed for curating culture through peer interactions. Student staff in university makerspaces can run trainings, develop programs, and support the student staff hiring process, which ultimately can affect student experience in the maker space. Interactions in university makerspaces can result in increased collaboration, creativity, leadership, and problem solving [1], so understanding the aspects that can affect student experience is important. To understand the student staff's strengths in makerspaces, this work seeks to answer the research questions:

- What are the assets student staff articulate through their experiences with others in the makerspace?

Researchers interviewed eight student staff members at a university makerspace in the engineering building at a large university. These semi-structured interviews were analyzed using grounded theory techniques and qualitative methods including inductive coding to develop a theoretical framework for interactions among student staff in university maker spaces. This research is part of a larger study to develop a theoretical framework examining the interactions within university makerspaces. The scope of this paper is focused on university makerspace student staff at one university and their assets when discussing their reason for using the makerspace. In the larger study, the theme of *Reason for Using Makerspace* emerged which includes students first experience in the makerspace, reason for continued interactions with the makerspace, and why they use the makerspace as a student staff member. Within this theme, students discussed their reason for using the makerspace that leveraged modes of Community Cultural Wealth (CCW) including social, resistant, linguistic, navigational, and aspirational [2]. This finding represents a nuanced reason for students to use, or continue using, a makerspace than previously researched reasons for using, including class projects [3] and architecture [4]. Student staff are the brokers of the makerspace, so understanding their reason for using the makerspace is essential to understanding how students use the makerspace. Future work will focus on the continuing to build the theoretical framework for interactions within university makerspaces through continued analysis and data collection from a wide variety of university makerspaces.

Keywords: university makerspaces, community cultural wealth, higher education, engineering education

Introduction

A key component of makerspace culture is the people in it, in particular the student staff. It is important to understand the experience of student staff in the makerspace as they can illuminate valuable feedback about their experiences and thus, the culture of the space. University makerspaces are generally facilities in universities with tools and spaces to craft, to create, and, essentially, to make. The administrative structure and the management of the space varies in target user population and organization. Student-run makerspaces are makerspaces with staff

who are undergraduate or graduate students. These students run the training, organization, hiring, and/or funding for these makerspaces. We are seeking to understand university makerspace student staff experiences in the makerspace. Through interviewing student staff in various positions, we found that student staff use the makerspace not just because of external factors, such as coursework, but also because of the assets they bring to the space.

What is a makerspace?

Makerspaces are prevalent in institutions across the world and especially prevalent in undergraduate engineering programs. Makerspaces are informal, opt-in STEM (science, technology, engineering, mathematics) spaces and are increasingly recognized for their potential to increase student access to and engagement with STEM [5], [6], [7]. Over the past two decades, research has highlighted the benefits of makerspaces, including engineering specific skills, such as prototyping, supporting student design projects, entrepreneurship, and innovation, [8], [9], [10]. Other research has highlighted the hegemonic norms of makerspaces. Maker culture, or the culture of makers in and outside of makerspace, has a white and masculine history which excludes those outside of these norms [12]. While makerspaces are not always reflective of maker culture, research shows that makerspace still uphold white and masculine norms[11]. Recent research [1], [12], [13] recognizes that the benefits of makerspaces are only available to those students who are involved in making experiences and postulate that makerspaces may be another STEM space that recreates and reinforces the hegemonic norms often present in the STEM domain. Therefore, it is important to understand the various reasons students get involved in makerspaces and focus on reinforcing positive and equitable practices.

Who is in a makerspace?

A variety of people enter university makerspaces including student staff members, full-time staff members of the makerspace, students, and faculty/staff of the university. Student staff members are undergraduate or graduate students who are hired to work in the makerspace. Their responsibilities include hiring, training, and organizing. Full-time staff members of the makerspace are staff members of the university who work full-time at the makerspace to hire students, train students, organize the space, stock the space with equipment and materials, fix equipment, and administrative tasks. Students in the space are generally only in the space during times when staff are available. Some makerspaces have restrictions on students entering the space based on major or course enrollment. Faculty/staff of the university who are not employed by the makerspace have similar restrictions and opportunities as students who enter the space. While each makerspace is uniquely staffed, research has identified key employees, often in the form of a manager, makerspace professional staff, and student staff. Recent research found that through these interactions in spaces, student staff shared they gained social skills [14] and technical skills [15] as a result of working in makerspaces.

Why do people enter a makerspace?

Makerspaces are often integrated into existing spaces and structures within engineering. For example, in engineering buildings across the United States, dedicated physical space and resources are used to house makerspaces. Additionally, the resources in makerspaces are incorporated into coursework including part of senior design projects. Recent research [16] recognized that sometimes these spaces can be difficult to find or intimidating to enter for some students. Other research [3] found that class projects or requirements are the primary reason

students enter these spaces including why they return. Outside of class requirements, students might also decide to enter these spaces because of a sense of an inclusive environment through artifacts or signage [17] or as a result of trainings and the need for repeated trainings [18].

Community Cultural Wealth in Engineering

Understanding who is using makerspaces and who has access to these spaces is inherently explored using critical frameworks which can help examine the structure, environment, participation, and pedagogy within STEM/Academic/University makerspaces [1]. One specific area where these frameworks can highlight the use of makerspaces is the experiences of student staff.

Community cultural wealth (CCW) is one such critical framework that identifies six different funds of wealth students gain throughout education, grounded in the wealth of Communities of Color [2]. The six funds of wealth are aspirational, linguistic, familial, resistant, social, and navigational capitals. CCW in engineering research surrounds topics such as nondominant student persistence [19], familial support of academic work ethic [20], [21], [22], student networks [23], and mentor guidance[24], [25], [26]. Using CCW is an avenue to conduct asset-based research, which highlights the strengths of students rather than weaknesses. This critical and assets-based approach makes explicit the strengths and assets of communities, in this case within makerspaces. CCW can frame the experiences of students who might not always be seen through an explicit and purposeful focus on assets they bring into the space. This is a personalized approach to understand the student staff's experience as opposed to the neutral outputs of their experience such as what they are creating or how many machines they are using in the space.

Research Question: What are the assets student staff articulate through their experiences with others in the makerspace?

Positionality

Both authors have experience using makerspaces at multiple universities. The first author occasionally used the student-run makerspace in their undergraduate university, especially for project-based courses. They have been trained in one machine at their graduate institution's student-run makerspace but have not been an active participant. The first author holds a degree in mechanical engineering and is pursuing graduate degrees in mechanical engineering. The second author first used and researched makerspaces during her post-doctoral studies. She is a STEM education researcher and was a high school science educator before her post-doctoral studies.

Methods

This paper is part of a larger study at multiple universities in the US. For this study, we conducted semi-structured interviews with 8 undergraduate student staff members of various roles in the same university makerspace. The makerspace is in a large Southwestern University with an undergraduate engineering population of about 6000 students. The interviews were conducted in 2021 in the makerspace in their engineering building. The interview protocol focused on the participants' experiences as student staff members. Questions include: 'Tell me

about yourself and how you got here?', 'What is your role in the makerspace?', 'What is being done well?', and 'What are some areas for improvement?' The interviews were between 30 minutes and one hour. They were then transcribed. We did not collect demographic information, so the demographic information we have for each student came up organically in conversation. All participants were in STEM majors. Due to the inconsistent data, we have on student demographics and the small sample size, we will not present the demographics such as gender, ethnicity, and year.

To analyze the data, we used grounded theory techniques to center the voices of the participants. The authors wrote memos throughout the process [27]. Throughout initial reading of the interview transcripts, the first author wrote memos to generate an initial set of codes based on in vivo and process coding. In vivo coding refers to the codes that emerge from the phrases students use verbatim which continues to center the voices of the participants [28]. Process coding describes participants actions or interaction and their consequences [28] which is an appropriate coding process to answer our research question. The code definition process is shown in Figure 1. After an initial round of coding using preliminary codes, many codes were condensed into larger codes. The authors met weekly to discuss the code definitions and changes. Of the ten codes that emerged, the authors chose to focus on one code further: *Reason for using makerspace*. Then, the first author secondary coded within *Reason for using makerspace*. They used protocol coding, which is a coding process using a previously established theory or framework [28], based on the Community Cultural Wealth framework[2].

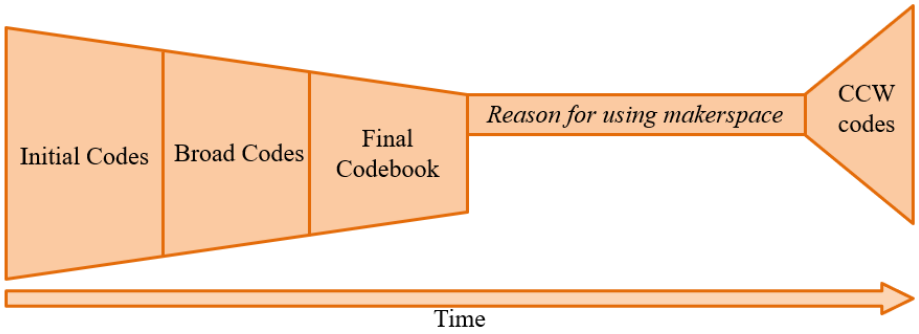

Figure 1: Timeline of code definition

Results

Students describe their experiences using the space as first time makerspace users, their experiences of continuing to use the makerspace, and their experiences of using the makerspace as student staff. While student staff members cited class projects as one of the reasons they use the space, they also cite community cultural wealth factors as well. Throughout this section, student staff pseudonyms are used to maintain anonymity.

Social Capital

Social capital refers to the connections and resources in a community. For student staff members, these community connections are often with other students or with makerspace staff members. The community resources include the physical space of the makerspace as well as the shared knowledge among those in the makerspace. For one senior staff member, Bridget, the robotics

club facilitated their first experience in the makerspace. Once they had spent sufficient time in the makerspace as non-staff member, they were approached by a then-student-staff member who introduced them to a university staff member who eventually hired them. Miriam was assigned to 3D print an object through a class and avoided this task, so their first interaction with the makerspace was when their friend, who happened to be a student staff member, invited Miriam to do homework in the space. Miriam later used the space to laser cut a pair of earrings because their cousin influenced them to use the laser cutter. Safiya was also influenced to use the makerspace by a family member. Safiya's sister was a student staff member and showed Safiya around the makerspace and influenced Safiya to learn how to use the machines in the makerspace. Class assignments are still influential, as Rene and Thiago both recall their first experiences using the makerspace was through a class project.

Resistant Capital

Resistant capital refers to the knowledge and skills gained through oppositional behaviors that challenge inequity, for example, using the makerspace as oppositional behavior which resulted in learning skills. Two student staff members, Bridget and Thiago, entered their undergraduate degrees as non-engineering majors. Bridget joined the robotics team and, through the skills they learned on the team, won the robotics competition. They said, "I know I'm an engineer. I'm gonna try and do everything I can to prove that to myself and find my way into the field a different way if it's not getting that degree." Before entering the engineering cohort, Thiago assumed the makerspace was for engineering students only, and they still went into the makerspace "every once in a while" to gain an understanding the space that they would eventually spend many semesters working in. Mary was intimidated to the enter the makerspace because they assumed the makerspace was for entrepreneurs and people who "create[d] their own projects." When they found an open-source 3D print file, they resisted the idea that the space was for entrepreneurs and said "I don't care. I'm just gonna go print them anyway" because they "thought [the prints] were gonna be a really nice gift to [their] sister." Rene was intimidated by the "masculine" look of the makerspace. When they went into the makerspace to make a 3D printed keychain for a class, they learned "how many women were on [the] staff."

Linguistic capital

Linguistic capital refers to intellectual and social skills gained through multiple forms and styles of communication. In makerspaces, linguistic capital translates to the style of communication associated with machining and machine usage instructions. Bridget recalls being offered a job at the makerspace because they "know how everything works" and they were able to effectively communicate with the university staff members. Rene recalls that they "couldn't tell a Phillips head... from a star or a screw," and through their continued participation in the makerspace, they learned the machining terminology. Thiago was familiar with "all the basic construction tools" because their "Dad was a carpenter" which led to their role as a trainer in the makerspace.

Navigational Capital

Navigational capital refers to skills related to being able to maneuver a social environment. Mary was able to identify points of contact within the space who were able to guide their projects and answer questions. Rene recalls that one of their friends entered the makerspace and left because they didn't know who to ask or where to begin on a project, so their friend never returned to the space.

Aspirational Capital

Aspirational capital refers to the ability to maintain hopes in the face of real and perceived barriers. Bridget experiences access barriers in classroom settings, especially labs, and they find the makerspace "nice to be in... and have a disability because I don't think I've ever really felt at a huge disadvantage." Bridget said, "[I] feel empowered just because I have that time and I've proven to myself that I can do these things. I can do whatever."

Discussion

In eight semi-structures interviews, we found that student staff in makerspaces leverage multiple funds of community cultural wealth when using the university makerspace. Student staff use the makerspace more often than the average student, and their reasons for using the space shed light on how and why they continue using the makerspace and eventually become staff. Literature on why students do not use the space shows that students' perceptions of making, such as technical versus artistic, impacts initial usage and marginalizing experiences impacts continued participation [16], while literature on why students use the makerspace says that courses impact usage[3]. While students still mention coursework as a motivation for using the makerspace, their decisions are impacted by their experiences and forms of Community Cultural Wealth. The interviews with student staff highlight why students continued using the space and commit to helping others use the space.

Student staff leveraged social capital when deciding to end the makerspace. Social connections are an important factor in community building and networking. These peer connections are necessary not only for a sense of community—such as with friends as family—but also to building a professional network that many undergraduate students need to foster such as through clubs, classes, and among other makerspace staff members.

The oppositional behavior of students with resistant capital was using the makerspace. Students experience intimidation when entering a makerspace, especially if they do not feel they fit the mold of a makerspace user, whether that be an engineering student, an entrepreneur, or masculine. Student staff oppositional behavior was only in their first use of the makerspace. Resistant capital centers around challenging inequity. Inequity in makerspaces tend to be gendered [11], [29], as Rene points out, raced, and classed[13], and makerspaces also have a history of being inaccessible [30]. Understanding the inequities in makerspaces brings light to the forms of resistant capital students are leveraging when using makerspaces.

Linguistic capital is the least prominently discussed capital in STEM education literature [31]. Linguistic capital is commonly associated with bilingual communication, which did not show up in this data set. Language and vocabulary associated with professions and communities is also commonly discussed as linguistic capital. The students in this data set discussed the ways machining vocabulary and knowledge affected their use of the makerspace. Student staff's linguistic capital impacted their use and continued use of the makerspace.

Navigational capital when using the makerspace emerged as knowing who to ask. This knowledge can be readily fostered in makerspaces, as opposed to resistant and social capital. Navigational capital can be fostered through giving guidance on who to ask via signage inside the space, which has been discussed in prior research[32] and through websites or social media before students enter the makerspace. Rene also mentioned the idea of knowing where to begin. Because makerspaces are open-ended, students may not feel like they have a tangible reason to enter the makerspace, and if tutorials or predesign projects are provided by the space, that may be reason enough to use the makerspace.

Aspirational capital emerged for one student staff member, Bridget, who is disabled. They maintain hope about the accessibility of makerspaces in the face of barriers in their lab courses. Aspiration capital in makerspaces can be especially impactful considering the access barriers commonly found in makerspace [30]. While this instance of aspirational capital is singular, it is important to highlight how aspirational capital can be linked to disabled students in makerspaces, especially considering the inaccessibility of STEM and makerspaces [30].

Limitations

As previously stated, the researchers do not have consistent demographic information about the participants. The authors recognize that including participant demographics, including race and gender when using a critical framework provides important context. The findings of this descriptive study contain self-identifications of gender and race, particularly in the Resistant Capital code. This study focuses on the assets of student staff which are included regardless of race and gender. Future work may focus on the impact of student's background on their assets in makerspaces. Additionally, student staff capitals were coded as single capitals, but importantly, capitals can overlap and influence each other. For example, a student's social capital can influence their navigational capital.

Implications and Future work

Implications from this study include the importance of recognizing the student experience in the space, especially of student staff. Those who support makerspaces should consider including the assets of students in their criteria for hiring and training student staff members in the space. Outside of hiring practices, makerspace stakeholders should consider the assets students bring into the space as they design and implement training for students, faculty, and staff who use the makerspace.

The results of this study are a foundational step in the grounded theory analytical process and represent a step forward in the creation of a theory that captures the experiences in interactions in makerspaces. The future work of the authors and others interested in supporting the assets of the students in the space should center the capitals students engage in as they use and support others in makerspaces. Our future work will focus on analyzing the current data set further. 'Reason for using makerspace' is just one of the broad codes from the interview analysis, and we plan to go

through the broad codes using CCW as a framework. This set of interviews is within one university makerspace, so future work will also include a broad range of university makerspaces including university makerspaces from different regions and of different sizes. This work can be used to inform ways to amplify these funds of knowledge in makerspaces.

References

[1] M. E. Andrews and A. Boklage, "Supporting inclusivity in STEM makerspaces through critical theory: A systematic review," *J. Eng. Educ.*, p. jee.20546, Jul. 2023, doi: 10.1002/jee.20546.

[2] T. J. Yosso, "Whose culture has capital? A critical race theory discussion of community cultural wealth," *Race Ethn. Educ.*, vol. 8, no. 1, pp. 69–91, 2005, doi: 10.1080/1361332052000341006.

[3] M. Josiam, A. Patrick, M. Andrews, and M. Borrego, "Makerspace Participation: Which Students Visit, Return, and Why?," in *2019 ASEE Annual Conference & Exposition Proceedings*, Tampa, Florida: ASEE Conferences, Jun. 2019, p. 33075. doi: 10.18260/1-2--33075.

[4] J. M. Hughes and L. J. Morrison, "Innovative learning spaces in the making," presented at the Frontiers in Education, Frontiers Media SA, 2020, p. 89.

[5] L. Martin, "The promise of the maker movement for education," *J. Pre-Coll. Eng. Educ. Res. J-PEER*, vol. 5, no. 1, p. 4, 2015.

[6] W. Roldan, J. Hui, and E. M. Gerber, "University makerspaces: Opportunities to support equitable participation for women in engineering," *Int J Eng Educ*, vol. 34, no. 2, pp. 751–768, 2018.

[7] V. Wilczynski, "Contributions of Academic Makerspaces to Design Education," *Des. Educ. Today Tech. Contexts Programs Best Pract.*, pp. 91–114, 2019.

[8] C. R. Forest *et al.*, "The Invention Studio: A University Maker Space and Culture.," *Adv. Eng. Educ.*, vol. 4, no. 2, p. n2, 2014.

[9] V. Wilczynski, J. Zinter, and L. Wilen, "Teaching engineering design in an academic makerspace: Blending theory and practice to solve client-based problems," in *2016 ASEE Annual Conference & Exposition*, 2016.

[10] V. Wilczynski and R. Adrezin, "Higher education makerspaces and engineering education," in *ASME International Mechanical Engineering Congress and Exposition*, American Society of Mechanical Engineers, 2016, p. V005T06A013.

[11] M. Tomko, M. W. Alemán, W. Newstetter, R. L. Nagel, and J. Linsey, "Participation pathways for women into university makerspaces," *J. Eng. Educ.*, vol. 110, no. 3, pp. 700–717, Jul. 2021, doi: 10.1002/jee.20402.

[12] A. C. Barton and E. Tan, *STEM-rich maker learning: Designing for equity with youth of color*. Teachers College Press, 2018.

[13] S. Vossoughi, P. K. Hooper, and M. Escudé, "Making Through the Lens of Culture and Power: Toward Transformative Visions for Educational Equity," *Harv. Educ. Rev.*, vol. 86, no. 2, pp. 206–232, Jun. 2016, doi: 10.17763/0017-8055.86.2.206.

[14] L. Z. Yamout and M. S. Harb, "Engineering Students Managing a University Makerspace: A Means to Cultivate 21st Century Skills," *ISAM*, 2023.

[15] B. D. Chambers, Z. D. Dowell, and N. Bedard, "Evaluation of Undergraduate Staff Experiences and Infrastructure in a First-Year Engineering Makerspace," 2023.

[16] M. E. Andrews and A. Boklage, "Spaces and Practices within University Makerspaces," in *2023 IEEE Frontiers in Education Conference (FIE)*, IEEE, 2023, pp. 1–5.

[17] M. Melo, L. March, K. Hirsh, and E. Arnsberg, "Description framework of makerspaces: Examining the relationship between spatial arrangement and diverse user populations," *J. Assoc. Inf. Sci. Technol.*, vol. 74, no. 5, pp. 506–516, May 2023, doi: 10.1002/asi.24741.

[18] M. V. Anand, A. J. Murrison, and A. Sears, “Catalysts of Creation: How Student-Run Workshops Influence Makerspace Participation 7th International Symposium on Academic Makerspaces,” *ISAM*, 2023.
[19] S. L. Dika, M. A. Pando, B. Q. Tempest, and M. E. Allen, “Examining the cultural wealth of underrepresented minority engineering persisters,” *J. Prof. Issues Eng. Educ. Pract.*, vol. 144, no. 2, p. 05017008, 2018.
[20] E. Longoria, “Success stems from diversity: The value of Latinas in STEM,” California State University, Northridge, 2013.
[21] C. de las Mercédez, “Patterns of persistence of Latinas in science, technology, engineering, and mathematics (STEM) degree programs: A mixed method study,” 2015.
[22] C. Peralta, M. Caspary, and D. Boothe, “Success factors impacting Latina/o persistence in higher education leading to STEM opportunities,” *Cult. Stud. Sci. Educ.*, vol. 8, pp. 905–918, 2013.
[23] M. L. Singer, L. T. Schlemer, E. E. Liptow, and K. C. Chen, “Community: Voices from a small cohort,” in *2018 ASEE Annual Conference & Exposition*, 2018.
[24] D. C. Braun, C. Gormally, and M. D. Clark, “The Deaf Mentoring Survey: A Community Cultural Wealth Framework for Measuring Mentoring Effectiveness with Underrepresented Students,” *CBE—Life Sci. Educ.*, vol. 16, no. 1, p. ar10, Mar. 2017, doi: 10.1187/cbe.15-07-0155.
[25] T. Coronella, *Validation theory into practice: Asset-based academic advising with first-generation Latina engineering college students*. Arizona State University, 2018.
[26] S. R. Rosbottom, “Engineering success: Undergraduate Latina women’s persistence in an undergradute engineering program,” The University of Texas at San Antonio, 2016.
[27] M. B. Miles, A. M. Huberman, and J. Saldaña, *Qualitative data analysis: a methods sourcebook*, Third edition. Thousand Oaks, Califorinia: SAGE Publications, Inc., 2014.
[28] J. W. Creswell and J. W. Creswell, *Qualitative inquiry and research design: choosing among five approaches*, 3rd ed. Los Angeles: SAGE Publications, 2013.
[29] A. M. Schauer, Z. Klesmith, and K. Fu, “Proficient in Pink? Exploring the Perceived Impact of GenderStereotyped Personal Protective Equipment on Women in Makerspaces,” *ISAM*, 2022.
[30] D. Bar-El and M. Worsley, “Making the maker movement more inclusive: Lessons learned from a course on accessibility in making,” *Int. J. Child-Comput. Interact.*, vol. 29, p. 100285, 2021.
[31] M. Denton, M. Borrego, and A. Boklage, “Community cultural wealth in science, technology, engineering, and mathematics education: A systematic review,” *J. Eng. Educ.*, vol. 109, no. 3, pp. 556–580, Jul. 2020, doi: 10.1002/jee.20322.
[32] M. (Maggie) Melo and R. Rodney, “The Power of First Impressions: Exploring the Design Impact of ‘Small Details’ and Signage for First-time Makerspace Users 7th International Symposium on Academic Makerspaces,” *ISAM*, 2023.