Board 238: Designing this Space for Whom? Characterization of Makerspace Non-users

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1 Introduction & Background

Engineering-focused academic makerspaces are a growing part of the higher education landscape. Created to supplement classroom instruction and expose students to experiential learning opportunities, researchers define academic makerspaces as sites where users learn, share, and create new knowledge through the act of building physical objects supported by expertise from mentors or staff members [1]. Prior work has found many benefits to makerspace participation. Students engaged in design and fabrication processes enhance their skills in creativity [2], prototyping [3], teamwork [4], and other interpersonal skills [4], [5], [6], [7], [8]. Barrett suggests these benefits result from building physical objects and participating in informal learning environments and communities [9]. Thus, students must be actively involved in the makerspace and community to reap the identified benefits. However, Barton et al. found little evidence demonstrating the involvement of diverse audiences in makerspaces [10]. A sizable group of students is not participating in makerspaces, thereby missing out on the documented benefits.

Research suggests there is a caveat to the democratizing and transformative nature of makerspaces, where technology-oriented makerspaces fall prey to the marginalizing norms within STEM and engineering environments [11], [12]. To address this issue, an emerging body of research focuses on creating inclusive makerspaces. An inclusive makerspace intentionally creates a safe space for students to foster meaningful relationships and create connections in the social fabric of the makerspace [11], [13]. To have an inclusive makerspace, all student participants must have a strong sense of belonging [11], [14]. Fostering a culture that engenders belonging in participants requires makerspace leaders and administrators to critically question how the environment and culture of the makerspace systematically marginalize certain groups from participating and succeeding in these spaces [15]. To ensure that the makerspace does not reinforce a “closed loop” culture, makerspace designers should reflect on who is not present in the makerspace and the potential barriers to participation and belonging present in the current makerspace design [11]. This can be difficult to achieve because it is hard to target students for outreach when little is known about them.

Drawing bounds around who uses and does not use makerspaces is complex. Einarsson’s discussion on sustaining library makerspaces described participation as unpredictable and not fixed [16]. This work seeks to close the gap in understanding the characteristics of students who do not currently participate in makerspaces at this academic institution. Defining potential markers of non-usage will aid in the following steps of inquiring why they do not engage. Literature suggests that researchers and designers of makerspaces should be intentional and genuine about understanding diversity, not through the boxing in of individuals based on

identities but considering the complex, intersecting identities and factors related to makerspace usage [17].

The research team attempts to understand why students do or do not participate by briefly exploring their motivations toward makerspaces. Other makerspace literature has used motivational constructs such as interest/enjoyment and perceived usefulness in empirical studies on making[18]. This study evaluated three individual motivation metrics: perceived comfort, perceived usefulness, and perceived enjoyment. Future work seeks to provide insight into the nuances of makerspace design using information gathered from the identified pool of students who do not participate in makerspaces. To address this gap in student involvement in makerspaces at our academic institution, this study seeks to answer the following research questions:

RQ1: What are the characteristics of students that do not engage in makerspaces?
RQ2: How does time affect the motivations of both users and non-users toward makerspaces?

This paper explores these questions by surveying first-year engineering students about their participation in and perceptions of makerspaces. This work can be used by other makerspace researchers to inform their understanding of the student population not reached by makerspaces.

2 Methods

A recommendation made within the literature to create an equitable makerspace is to critically consider who is using the space and who is not, intending to build a culture of belonging that accounts for those who may use the makerspace in the future [11]. To identify potential users, we surveyed first-year undergraduate engineering students to capture their intention to participate in academic makerspaces. This study reports on work done as part of a larger study that follows the paths of first-year students at two academic institutions, tracking their participation and perceptions of makerspaces over four years. Quantitative data were collected from two online surveys that were distributed at the beginning of the Fall 2022 semester and the end of the Winter/Spring 2023 semester. Each survey took approximately 10 minutes to complete and consisted of a series of Likert-type and single-selection questions about their attitudes/motivations toward makerspaces and psychosocial assessments of their engineering identity, sense of belonging, and self-efficacies.

The survey instrument was designed with validated scales to measure engineering self-efficacy [19], design self-efficacy [20], and students' sense of belonging [21]. The first survey also asked students to self-report demographic items, such as gender identity, sexual orientation, race/ethnicity, nationality, status as first-generation college students, estimated family income, plans to work during the academic year, and if they would identify as having a disability. The

instrument also asked students what forms of making they had previous experience with, for example, woodworking or making with textiles. Students' perceived attitudes toward makerspaces were also collected through the form of Likert-type questions that focused on how they would agree or disagree with a statement like "I would feel comfortable walking into a makerspace." This question style was asked for the student's perceived enjoyment of using a makerspace, the makerspaces perceived usefulness, and the student's intention to participate in a makerspace.

Of the estimated 1,010 first-year students, 174 responded to the initial survey distributed in October 2022 (17.2% response rate). From the initial set of students questioned from the first survey, 119 participated in the second survey distributed in March 2023. The sample was narrowed to students who responded to both surveys. Respondents who were missing values for any of the factors of interest were removed by listwise deletion. This left an analytical sample of 73 students; 43.8% of these students, $n = 32$, visited the makerspace and $n = 41$ did not. To understand the characteristics of the students within the sample, descriptive statistics were generated. Independent sample t-tests were also conducted on samples of students that participated in makerspaces and those that did not for the sense of belonging scores measured in the two surveys.

3 Results

Table 1 provides the demographic breakdown for the participants in the analytical sample. Participants' responses to "During this academic year (2022 - 2023), did you engage with any makerspaces on campus?" were used as a grouping factor.

Table 1: Student Demographics

	Entire Sample	***Used Makerspace***	***Did not use makerspace***
	$n = 73$	$n = 32$	$n = 41$
Race/Ethnicity			
Asian	25	12	13
Black	7	4	3
Hispanic or Latinx	3	1	2
White	34	13	21
Multiracial	4	2	2
Gender Identity			
Cis-men	35	17	18
Cis-women	35	14	21

Non-binary, Transgender, Third Gender	3	1	2
Sexual Orientation			
Straight	55	24	31
LGBQQ	18	8	10
Disability Status			
Selected at least one disability	14	9	5
Did not select a disability	59	13	36
First Generation			
Continuing Generation	59	22	37
First Generation	14	10	4
Estimated Family Income			
Less than 100k	29	11	18
100k - 199k	25	13	12
200k and higher	19	8	11
Plans to work during the academic year			
No or maybe	44	17	27
Working under 10 hr	14	8	6
Working over 10 hr	15	7	8
Highest level of parent education			
No HS diploma	2	2	0
HS diploma or equivalent	7	6	1
Some college/postsecondary	3	2	1
Associate's (2-year) degree	2	0	2
Bachelor's (4-year) degree	18	4	14
Graduate or professional degree	41	18	23

Cross-tabulations and chi-square tests were conducted to examine whether there were statistically significant differences in makerspace engagement based on demographic factors.

Statistically significant differences were found in makerspace usage between first-generation and continuing-generation students, with a p-value of 0.0439. First-generation college students (71.4%) exhibited higher participation rates than continuing-generation students (37.3%). Among students with different levels of parental educational backgrounds, statistically significant differences were found in makerspace participation, with a p-value of 0.0219. Students with the highest level of parental education, such as an associate's degree or above, exhibit lower rates of participation in comparison to those below that level of education. This result must be taken cautiously as the sample sizes are pretty small, indicating lower levels of statistical power. No statistically significant differences in makerspace participation were found based on gender, race/ethnicity, sexual orientation, disability status, estimated family income, and student working status.

Students' motivations to engage in makerspaces, precisely their perceived comfort, enjoyment, and usefulness of makerspaces, were analyzed to answer why they do or do not participate. Figures 1 and 2 show the participants' perceived comfort in academic makerspaces before and after makerspace usage occurred during the 2022-2023 academic year. Students were asked to respond to the following prompt, "I would feel comfortable walking into a makerspace on campus," with how closely they agreed or disagreed with the statement. The students that did not participate in makerspaces were more likely to disagree with the statement that they would feel comfortable walking into a makerspace. This trend remained the same at the end of the Winter/Spring 2023 term. The chi-square test results showed statistically significant differences in perceived comfort between makerspace users and non-users for the baseline (p-value: 0.00955) and end-of-academic year metrics (p-value: 7.53e-05).

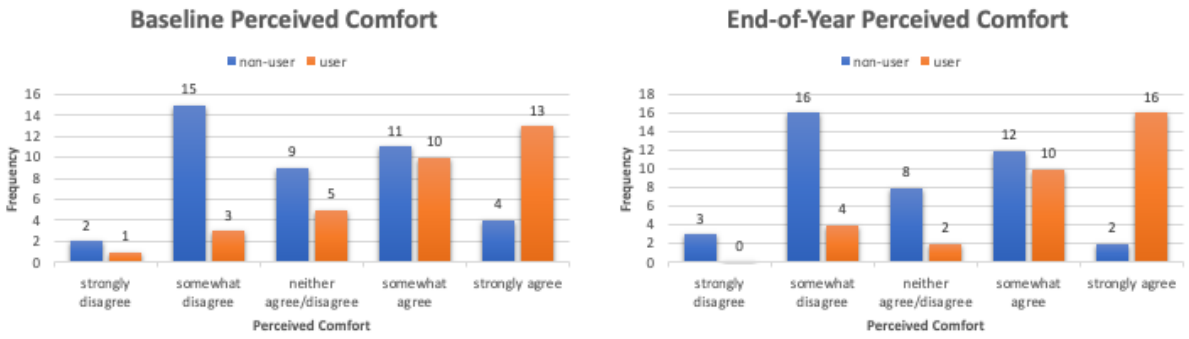

Fig 1 & 2: Perceived comfort scores for participants (users vs. non-users)

Figures 3 and 4 show the participants' perceived enjoyment of using academic makerspaces before and after makerspace usage occurred during the 2022-2023 academic year. Students were asked to respond to the following prompt, "Engaging in makerspaces sounds enjoyable to me," with how closely they agreed or disagreed with the statement. The students who participated and

did not participate in makerspaces exhibited a similar trend with high levels of perceived enjoyment. This trend remained the same at the end of the Winter/Spring 2023 term, with no students strongly disagreeing with the prompted question. The chi-square test results showed statistically significant differences in perceived comfort between makerspace users and non-users for the baseline (p-value: 0.005354) and end-of-academic year metrics (p-value: 1.471e-07).

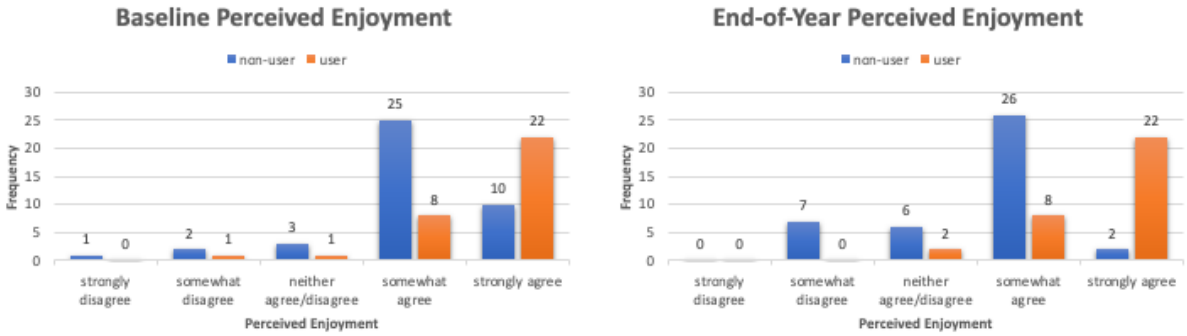

Fig 3 & 4: Perceived enjoyment scores for participants (users vs. non-users)

Figures 5 and 6 show the participants' perception of academic makerspaces usefulness before and after makerspace usage occurred during the 2022-2023 academic year. Students were asked to respond to the following prompt, "Engaging in makerspaces sounds useful to me," with how closely they agreed or disagreed with the statement. Both students that used makerspaces and those that did not mostly agree with the statement that makerspaces are useful, the difference being the strength of agreeance (non-users somewhat agreeing vs. users strongly agreeing). Figure 6 depicts the changes in the strength of agreeance for students who did not use makerspaces, with four students somewhat disagreeing with the statement and three neither agreeing/disagreeing. The students that used makerspaces saw a trend towards higher levels of agreeance, with 25 strongly agreeing to makerspaces perceived usefulness. The chi-square test showed statistically significant differences in perceived comfort between makerspace users and non-users for the baseline (p-value: 0.004079) and end-of-academic year metrics (p-value: 7.707e-08).

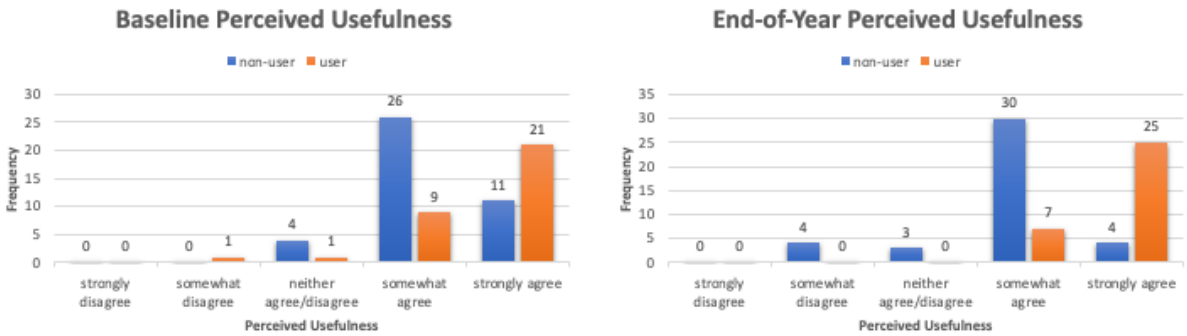

Fig 5 & 6: Perceived usefulness scores for participants (users vs. non-users)

To evaluate the rate of change in motivation scores from the baseline to end-of-year surveys for students who used or did not use makerspaces, a summary statistic (rate of change) of each motivation score was calculated and analyzed using independent samples two-sample t-test. Results from the two-sample t-test comparing the change in perceived comfort by makerspace usage indicated no statistically significant difference in the rate of change for those having used makerspaces (M: 0.219) and those not (M: -0.146). Differences in the change of perceived enjoyment across makerspace usage were found to be statistically significant (p-value: 0.0213), with those not engaged in makerspaces having a more significant negative trend (M: -0.439) and those involved having a slightly positive trend (M: 0.0313). Comparisons between the perceived usefulness of makerspaces for users and non-users of the makerspace were statistically significant (p-value: 0.00345). Non-users of academic makerspaces exhibited a negative trend (M: -0.341), shifting towards lower levels of agreeance, and users of makerspaces exhibited a positive trend (M: 0.219), moving towards higher levels of agreeance.

4 Discussion

Contrary to our underlying assumptions, no clear delineation of makerspace usage was found based on gender, race/ethnicity, sexual orientation, or ability status. This strengthens the claim that targeting makerspace non-users is difficult because there are no clear boundaries to define who does not use these spaces. The differences in characteristics across users and non-users are more nuanced than just targeting a certain demographic or affinity group. These results must also be understood within the context of the institution where the study was conducted. Underrepresented minority students (Black, Hispanic, Native American, Hawaiian, or multi-racial) comprise 16% of the enrolled undergraduate population at the College of Engineering for this institution. Women comprise 31% of the enrolled undergraduate engineering population. The pool of traditionally underrepresented students in engineering and makerspaces [10] is small, which would lead to difficulties in finding evidence of differences in makerspace engagement based on these demographics. This institution also requires students to apply directly to the College of Engineering, narrowing the sample population to students interested in engineering. Selection bias among the sample, along with small sample sizes, should be taken into thorough consideration when interpreting these results.

Differences in makerspace engagement were statistically significant across two dimensions, first-generation status and the highest level of parental education, which are inherently related. Patterns in usage were at odds with the initial assumptions of first-generation participation rates in academic makerspaces. First-generation students exhibit higher levels of engagement than continuing-generation students. A similar pattern is present in the differences in usage for students with parents with educational attainment lower than an Associate degree, having higher

participation rates, than students with higher levels of parent education, which exhibit lower participation rates. Caution should be taken when interpreting the result, as Table 1 shows that the sample sizes of students with lower parental educational attainment were small, and the majority of the population having parents have the highest levels of parental education attainment. This could imply that first-generation students (students with lower levels of parental education) are more likely to be exposed to making processes at home, making them more likely or more comfortable to engage in these spaces. To substantiate this inference, qualitative research must be conducted to understand why first-generation students engage in makerspaces at higher rates.

Although first-generation status is its own social identity, it is highly related to low socioeconomic status, as first-generation students face similar challenges while navigating the college experience [22]. Understanding these results within the context of the academic institution in which this study is situated, as socioeconomic status plays a large role in the culture and environment of this institution. To be considered to receive aid for the full cost of tuition as an in-state student, the parents must make below 75,000 USD. The proportion of in-state undergraduate students enrolled in 2021 who met the qualifying criteria was 31%. The percentage of out-of-state students, making up more than 45% of enrolled students, with an expected family income above 150,000 USD was 77%. A guide on how to navigate college at this specific institution while being “not rich” was created in 2018 by a group of undergraduate students to provide resources and tips to those from under-resourced backgrounds. This implies clear differences in the experiences of students with different socioeconomic backgrounds, who comprise a larger proportion of the overall student population, giving sufficient power to statistical tests.

Attempting to answer *why* students engage in and do not engage in makerspaces, our research team explored motivation scores associated with makerspace use. Non-users of makerspaces tend to trend towards lower scores of perceived comfort and a lower level of agreeance (somewhat agree) to the usefulness of and enjoyment in using these spaces. Students who did not engage in the makerspace experienced a reduction in all individual motivation metrics. Users tend to have higher levels of perceived comfort and strong agreeance with the usefulness and enjoyment of using makerspaces. Over time, those who participated in makerspaces tended to move positively and agree more with all the individual motivation scores. The rate at which students changed their motivation scores was statistically different for perceived enjoyment and usefulness, with non-users showing shifts in larger magnitudes. Non-users are already less enthusiastic about the enjoyment and usefulness of makerspaces and become even less enthusiastic over time. Therefore, it seems the key motivation marker to be aware of is perceived comfort, as users and non-users tended to see makerspaces as useful and enjoyable learning sites.

This study found that usage is nuanced; who would fall within the lines of a “non-user” or “user” of a makerspace is complex and requires further analysis. The lack of significance based on race and gender for makerspace usage is a surprise, suggesting that demographics are not a key indicator of makerspace involvement at this institution, contrary to overall trends [10]. This is likely due to the selection of the student population. All the first-year students surveyed had already chosen the College of Engineering and were admitted based on past success in engineering-related activities. Among survey respondents, a clear differentiation between users and non-users is their perceived comfort levels within the makerspace, with non-users having lower comfort scores over time. Therefore, the population to target, non-users, should be focused on those who feel uncomfortable with the current design of makerspaces. Makerspace leaders, decision-makers, and designers should create/design spaces that address the attributes or features of makerspaces that lead to students' low levels of perceived comfort.

5 Conclusion and Future Work

In conclusion, this work sought to understand the characteristics of makerspace non-users based on their demographic information and perceived attitudes toward makerspaces. Limited work has been done to document the process of understanding the population of students that the makerspace does not reach. Quantitative data was analyzed from two surveys distributed to first-year engineering students. To continue progressing in developing an inclusive makerspace through the consideration of non-users when designing makerspaces, we answered the following research questions:

RQ1: What are the characteristics of students that do not engage in makerspaces?

Differences in makerspace usage based on gender, race/ethnicity, ability status, and other demographic characteristics were not found to be statistically significant. No clear lines were drawn using conventional identity markers to characterize non-users or users. First-generation status and parent education were the only demographic characteristics with statistically significant differences in makerspace participation. This could likely mean that a more nuanced understanding of the differences between students who engage in makerspaces and those who do not is required. Future research should continue to explore the characteristics and demographic makeup of non-users, potentially using an intersectional analysis.

RQ2: How does time and usage/non-usage affect student motivations towards makerspaces?

Students who did not participate in makerspaces displayed lower levels of perceived comfort within makerspaces, with the scores becoming more negative over time. Users of makerspaces exhibited a positive change in their perceived comfort level, moving towards higher levels of agreeance. Both users and non-users rated their perceived usefulness of and enjoyment in makerspaces as positive, with differences in the strength of their agreeance. The change over time for non-users was larger in the negative

direction than for users. Over time, usage positively impacts students' motivations towards makerspaces (enjoyment and usefulness at a different rate), and non-usage negatively impacts students' motivations.

To further explore the nuanced nature behind usage, statistical analyses will be conducted using a new dataset of first-year engineering students from two academic institutions. Quantitative analyses using an intersectional lens will be conducted to determine if there are potentially significant differences in makerspace usage based on multiple intersecting identities. To further investigate why students do or do not engage in makerspaces, semi-structured interviews will be conducted to learn more about students' perceived comfort, the potential barriers or catalysts to participation, and prospective design opportunities in makerspaces.

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