# Do I Fit In? Examining Student Perceptions of Belonging and Comfort in University Makerspaces

## 7th International Symposium on Academic Makerspaces

ISAM 2023 Paper No.: XX

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**Abstract**

The growing popularity of progressive education pedagogies combined with the continued rise of the maker movement has propelled knowledge and interest in makerspaces across education. As a result, makerspaces have become a common sight on college campuses around the world. These spaces offer students a unique opportunity to apply the hard and soft skills learned in the classroom to projects with real consequences. Students learn to take ownership of their work and experiment and iterate until they are proud of their results. Through this process they grow in design self-efficacy, innovation, and collaboration skills. Makerspaces are a powerful tool in the hands of university professors, but not all students benefit from them equally. Many students still face real or perceived barriers to entry caused in part by a lack of comfort and confidence in the space. This study seeks to examine students' sense of belonging at a university makerspace and determine how gender, major, study locations, and classes affect this sense. Online surveys were distributed to students who used the makerspace in Fall 2022 and Spring 2023. Students answered a series of Likert style questions about how they feel in the space and statistical tests were used to determine correlation and significance of the results. It was found that sense of belonging in the space overall was high, but that females, non-mechanical engineering majors, and students who did not study in the space reported statistically lower sense of comfort. Suggestions are given to makerspace administrators of how to address and avoid these gaps in belonging and make the space more inclusive and welcoming to all students.

**Introduction**

While few people identify themselves as inventors, many relate to the word "maker" in one way or another [1]. Makerspaces exist as places where makers of all backgrounds and abilities can come together to brainstorm, design, build, and collaborate through a variety of mediums. They can be found as stand-alone centers, or be housed within museums, schools, and libraries. As the concept of makerspaces and the interest in them has grown, so have the number of universities building spaces for students and integrating them into curriculum. University makerspaces vary largely in structure and application from campus to campus, but all provide informal learning platforms for students [2].

Prior work on academic makerspaces has shown the advantages these spaces afford to the students who use them. Benefits include increased confidence, technical knowledge, communication ability, design self-efficacy, motivation, and innovation [3-7]. Additionally, makerspaces provide a safe place for students to practice the problem-solving skills they are learning in their coursework and a social gathering place to connect with likeminded individuals [6, 8, 9]. Despite all these benefits, many students still face real or perceived barriers to entry based on factors such as gender, major, race/ethnicity, and technical knowledge [10-12].

According to Maslow's Hierarchy of Needs, people are motivated by a need to belong [13]. When students feel as though they don't belong in a space, they fail to fully reap the benefits afforded. Lack of belonging may also hurt their academic performance, self-efficacy, and persistence in their major [14-16].

This paper aims to address two research questions:

RQ1) How do students perceive their sense of belonging and inclusion in the makerspace?

RQ2) How is sense of belonging affected by factors such as gender, major, study habits, and classes taken?

Understanding how students feel allows makerspace staff to evaluate their current practices and make changes to help students feel more comfortable and confident and thus more completely benefit from the space.

**Methods**

The makerspace studied is found in a mechanical engineering building in a large, STEM focused research university in the Southeast United States. The makerspace is home to a variety of equipment including wood and metal shop tools, laser cutters, 3D printers, electronics tools, and craft tools. Students, faculty, and staff of the university are invited to use the space for personal, class, club, and research projects. While the space is located in a primarily mechanical engineering building, students of all majors are encouraged to make use of its resources. Access is provided free of cost, but users are expected to bring their own raw materials for the wood and metal shops. The makerspace is run by student volunteers who staff in exchange for after-hours access.

Data for this study were collected by means of an online Qualtrics survey distributed to students who recently used the

makerspace. The survey took approximately 15 minutes to complete and asked questions about prior makerspace experience, demographics, tool usage, and sense of belonging [17, 18]. Only the sense of belonging questions and demographic questions were analyzed in this work, but the remainder of the survey was used as part of a larger, multi-semester study on student tool usage patterns [19-23]. Survey responses were collected in Fall 2022 and Spring 2023, resulting in a total population of N = 283. The two semesters of data were combined for the analysis.

Survey participants were recruited by standing outside the makerspace the last two weeks it was open each semester and inviting students to sign up to complete the survey. Students who expressed interest were asked to sign a consent form and then were paid $1 cash. At the end of the semester, these students were sent the survey via email. Additionally, mechanical engineering and interdisciplinary capstone students were invited to participate via a class announcement on the university's learning management system. All students who completed the survey were given a $20 Amazon gift card.

The belonging questions listed in the survey were taken from those developed by Nadelson, et. al. [17, 18]. Whenever the word "makerspace" appeared, the name of the specific makerspace studied was inserted. The questions were presented on a 5-point Likert scale where students read a series of statements and choose the extent to which they agreed or disagreed. The first 10 questions were positively phrased, while the last 3 questions were negatively phrased. The scale for the negatively worded questions was reversed for the analysis and the converse statements are listed in the results. This scale used is in Table 1. Due to the Likert style questions and the non-normality of the results, the data were analyzed using the Mann Whitney U statistical test. This is a non-parametric alternative to the independent samples t-test.

***Table 1: Likert Scale for Positively and Negatively Worded***

| Positively Worded | Likert Scale | Negatively Worded |
|---|---|---|
| 1 | Strongly Disagree | 5 |
| 2 | Disagree | 4 |
| 3 | Neutral | 3 |
| 4 | Agree | 2 |
| 5 | Strongly Agree | 1 |

**Results**

Table 2 presents the mean and standard deviation scores for each of the thirteen questions. The three highest scoring statements were "I feel comfortable in engineering classrooms", "I feel like I can really trust the student workers in the makerspace" and "I feel comfortable in the makerspace" each of which had an average between Agree and Strongly Agree. Most of the other statements had mean scores between Neutral and Agree. Overall, sense of belonging was high in the makerspace. The lowest scoring statement was "I prefer to work with others in the makerspace" which scored between Disagree and Neutral.

***Table 2: Mean and Standard Deviation Values for Belonging Questions***

| | Mean | Std. Dev |
|---|---|---|
| I feel comfortable in the makerspace. | *4.10* | 0.99 |
| I feel like I can really trust the student workers in the makerspace. | *4.20* | 0.87 |
| I feel comfortable in engineering classrooms. | *4.22* | 0.84 |
| I feel valued in the makerspace. | 3.74 | 1.00 |
| I feel valued in engineering classrooms. | 3.94 | 0.93 |
| I enjoy working on group projects in the makerspace. | 3.96 | 0.98 |
| I'd like the chance to interact with the student workers in the makerspace more often. | 3.92 | 1.01 |
| I have made friends through my work in themakerspace. | 3.36 | 1.25 |
| I'd like a chance to interact with other students in the makerspace more often. | 3.79 | 0.96 |
| I feel like I can really trust fellow students in the makerspace. | 3.93 | 0.92 |
| I don't feel respected by my peers in the makerspace. | 3.90 | 1.12 |
| I prefer to work alone in the makerspace. | *2.74* | 1.15 |
| I feel disconnected to fellow students in the makerspace. | 3.50 | 1.11 |

Statistics in Table 3 compare results for men (n = 164) and women (n = 84) students. It was found that men reported a statically higher sense of comfort in the makerspace (Z = -3.264, p = 0.001*) and in engineering classrooms (Z = -3.018, p = 0.003*). Additionally, they felt statistically more valued in their engineering courses (Z = -2.865, p = 0.004*).

***Table 3: Mann Whitney U Test Results for Men (M) vs Women (W)***

| | Mean Rank (M) | Mean Rank (W) | Z | p-value |
|---|---|---|---|---|
| I feel comfortable in the makerspace. | 132.91 | 103.66 | -3.264 | 0.001* |
| I feel like I can really trust the student workers in the makerspace. | 123.11 | 122.79 | -0.036 | 0.971 |
| I feel comfortable in engineering classrooms. | 120.44 | 95.00 | -3.018 | 0.003* |
| I feel valued in the makerspace. | 124.71 | 111.92 | -1.399 | 0.162 |
| I feel valued in engineering classrooms. | 119.19 | 94.39 | -2.865 | 0.004* |
| I enjoy working on group projects in the makerspace. | 110.64 | 97.91 | -1.491 | 0.136 |
| I'd like the chance to interact with the student workers in the makerspace more often. | 117.58 | 126.23 | -0.957 | 0.338 |
| I have made friends through my work in the makerspace. | 118.10 | 103.85 | -1.573 | 0.116 |
| I'd like a chance to interact with other students in the makerspace more often. | 120.78 | 118.45 | -0.258 | 0.797 |
| I feel like I can really trust fellow students in the makerspace. | 121.18 | 125.11 | -0.440 | 0.660 |
| I feel respected by my peers in the makerspace. | 120.79 | 118.38 | -0.268 | 0.789 |
| I prefer to work with others in the makerspace. | 116.60 | 131.06 | -1.567 | 0.117 |
| I feel connected to fellow students in the makerspace. | 123.40 | 114.48 | -0.969 | 0.332 |

Sense of belonging was also evaluated based on major. A summary of the results for mechanical engineering students vs non-mechanical engineering students is shown in Table 4. Mechanical engineering students reported a statistically higher feeling of comfort in the makerspace ($Z = -2.067$, $p = 0.039$*), but none of the other results were statistically significant, indicating that major does not play a large roll in sense of belonging at this makerspace.

***Table 4: Mann Whitney U Test Results for Mechanical Engineering Majors (ME) vs Non-Mechanical Engineering Majors (Not ME)***

| | Mean Rank (Y) | Mean Rank (N) | Z | p-value |
|---|---|---|---|---|
| I feel comfortable in the makerspace. | 165.66 | 133.05 | -3.018 | 0.003* |
| I feel like I can really trust the student workers in the makerspace. | 144.84 | 139.21 | -0.532 | 0.595 |
| I feel comfortable in engineering classrooms. | 134.83 | 125.28 | -0.945 | 0.344 |
| I feel valued in the makerspace. | 149.98 | 133.10 | -1.555 | 0.120 |
| I feel valued in engineering classrooms. | 129.53 | 124.25 | -0.517 | 0.605 |
| I enjoy working on group projects in the makerspace. | 134.22 | 116.81 | -1.747 | 0.081 |
| I'd like the chance to interact with the student workers in the makerspace more often. | 140.63 | 136.57 | -0.374 | 0.708 |
| I have made friends through my work in the makerspace. | 163.08 | 118.62 | -4.164 | <.001* |
| I'd like a chance to interact with other students in the makerspace more often. | 156.08 | 131.39 | -2.273 | 0.023* |
| I feel like I can really trust fellow students in the makerspace. | 163.03 | 131.78 | -2.932 | 0.003* |
| I feel respected by my peers in the makerspace. | 147.31 | 133.91 | -1.251 | 0.211 |
| I prefer to work with others in the makerspace. | 150.67 | 134.24 | -1.485 | 0.138 |
| I feel connected to fellow students in the makerspace. | 156.23 | 131.79 | -2.250 | 0.024* |

Next, results from students who indicated that they studied in the space were compared to results of students who indicated that they do not study in the space. These statistics are found in Table 5. Those that studied scored statistically higher in sense of comfort in the makerspace ($Z = -3.018$, $p = 0.003$*). Additionally, their relations with other students in the space were reported as statistically higher in categories such as making friends through the makerspace ($Z = -4.164$, $p < 0.001$*), trust of other students ($Z = -2.932$, $p = 0.003$*), feeling connected with fellow students ($Z = -2.25$, $p = 0.024$*), and wanting to interact with other students in the makerspace more often ($Z = -2.273$, $p = 0.023$*).

***Table 5: Mann Whitney U Test Results for Students Who Study in the Space (Y) vs Those Who Do Not (N)***

| | Mean Rank (Y) | Mean Rank (N) | Z | p-value |
|---|---|---|---|---|
| I feel comfortable in the makerspace. | 165.66 | 133.05 | -3.018 | 0.003* |
| I feel like I can really trust the student workers in the makerspace. | 144.84 | 139.21 | -0.532 | 0.595 |
| I feel comfortable in engineering classrooms. | 134.83 | 125.28 | -0.945 | 0.344 |
| I feel valued in the makerspace. | 149.98 | 133.10 | -1.555 | 0.120 |
| I feel valued in engineering classrooms. | 129.53 | 124.25 | -0.517 | 0.605 |
| I enjoy working on group projects in the makerspace. | 134.22 | 116.81 | -1.747 | 0.081 |
| I'd like the chance to interact with the student workers in the makerspace more often. | 140.63 | 136.57 | -0.374 | 0.708 |
| I have made friends through my work in the makerspace. | 163.08 | 118.62 | -4.164 | <.001* |
| I'd like a chance to interact with other students in the makerspace more often. | 156.08 | 131.39 | -2.273 | 0.023* |
| I feel like I can really trust fellow students in the makerspace. | 163.03 | 131.78 | -2.932 | 0.003* |
| I feel respected by my peers in the makerspace. | 147.31 | 133.91 | -1.251 | 0.211 |
| I prefer to work with others in the makerspace. | 150.67 | 134.24 | -1.485 | 0.138 |
| I feel connected to fellow students in the makerspace. | 156.23 | 131.79 | -2.250 | 0.024* |

Finally, Table 6 shows the results of a comparison of students who were taking a class that required makerspace usage vs students who were not taking such as a class. The results imply that those who used the makerspace for class enjoy working with others in the space ($Z = -2.289$, $p = 0.022$*) more than students who did not use the space for class.

***Table 6: Mann Whitney U Test Results for Students Who Took a Class That Required Use of the Space (Y) vs Those Who Did Not (N)***

| | Mean Rank (Y) | Mean Rank (N) | Z | p-value |
|---|---|---|---|---|
| I feel comfortable in the makerspace. | 145.23 | 134.38 | -1.186 | 0.236 |
| I feel like I can really trust the student workers in the makerspace. | 137.91 | 143.85 | -0.663 | 0.507 |
| I feel comfortable in engineering classrooms. | 131.78 | 121.13 | -1.224 | 0.221 |
| I feel valued in the makerspace. | 136.27 | 137.95 | -0.182 | 0.856 |
| I feel valued in engineering classrooms. | 129.31 | 119.78 | -1.078 | 0.281 |
| I enjoy working on group projects in the makerspace. | 126.34 | 112.79 | -1.555 | 0.120 |
| I'd like the chance to interact with the student workers in the makerspace | 138.03 | 136.82 | -0.131 | 0.895 |
| I have made friends through my work in the makerspace. | 135.58 | 120.07 | -1.697 | 0.090 |
| I'd like a chance to interact with other students in the makerspace more often. | 139.63 | 133.69 | -0.649 | 0.516 |
| I feel like I can really trust fellow students in the makerspace. | 135.90 | 142.94 | -0.779 | 0.436 |
| I feel respected by my peers in the makerspace. | 131.65 | 143.92 | -1.348 | 0.178 |
| I prefer to work with others in the makerspace. | 128.70 | 150.19 | -2.289 | 0.022* |
| I feel connected to fellow students in the makerspace. | 132.50 | 143.92 | -1.233 | 0.217 |

## Discussion

Gender comparison showed that female students reported a lower sense of comfort both in makerspaces and the engineering classroom. This is consistent with prior work [18, 24, 25] and careful attention should be given to address this discrepancy. Tomko et. al. suggests that apprenticeship, catalyst activities, and positive female staff members are effective means to draw more women into makerspaces [26]. Other work emphasizes the need to make sure makerspaces appear inviting and supportive of beginners given the lack of confidence many women experience when first visiting a campus makerspace [24, 27].

Comparison by major showed a higher sense of comfort in makerspaces for mechanical engineering students, but no other significant results. This is both surprising and encouraging given the makerspace's prominent location in a large mechanical engineering building and several mechanical engineering classes that ask students to use the space. One possible way to resolve the remaining difference in comfort is for professors of other majors, specifically other engineering disciplines, to offer assignments that encourage students to enter the space, especially early in the curriculum.

Studying inside the makerspace was found to be highly related to students' sense of comfort and positive relations with other students in the space. However, this correlation does not necessarily indicate a causation. It is unclear whether students who study in the space improve their sense of belonging or students who feel as though they belong tend to study more in the space. Either way, university makerspace leadership should pay close attention to the quantity and location of their study and hang out space and use this correlation to encourage more people to enter and utilize the makerspace.

Class usage was not highly correlated with sense of belonging, though students who used the space for class reported statistically higher enjoyment of working with other people and making of friends. This suggests that instructors should continue to encourage hands on and makerspace related projects whenever possible as the collaborative environment encourages student teamwork.

## Conclusion

Online surveys asking questions about belonging were administered to university students who used a makerspace during Fall 2022 and Spring 2023. These results were analyzed generally, and then based on criteria of gender, major, study habits, and current classes to determine how each of these factors affects perceived sense of belonging. Overall, students reported a high sense of belonging, but factors such as gender and study habits did produce statistically significant differences. Male students reported higher sense of comfort in both makerspaces and engineering classrooms. Similarly, those who studied in the makerspace not only reported higher levels of comfort, but also higher degrees of friendship and trust for peers around them. Major and classes that require use of the makerspace also play a role in sense of belonging, though not as large. Makerspace staff should make use of this information when designing and running their spaces.

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