

Board 331: Making Space in a Makerspace: Increasing Belonging through Social Engagement

Prof. Jill Davishahl, Western Washington University

Jill Davishahl is Associate Professor and First Year Programs Director in the Engineering + Design department at Western Washington University. Jill's teaching, service, and research activities focus on enhancing the first year student experience by providing the foundational technical skills, student engagement opportunities, and professional skill development necessary to improve success in the major. Her current research focuses on creating inclusive and equitable learning environments through the development and implementation of strategies geared towards increasing student sense of belonging.

Audrey Boklage, University of Texas at Austin

Audrey Boklage is research assistant in the Cockrell School of Engineering at the University of Texas at Austin. Her current work is focused on exploring pedagogical moves and interactions within university makerspaces to create a theoretical lens to info

Making Space in a Makerspace: Increasing Belonging through Social Engagement

Abstract

In recent years, there have been many efforts to increase student sense of belonging in engineering as it has been shown to positively impacting student retention, persistence, and success. One promising venue for building student sense of belonging is the academic makerspace. Makerspaces provide a setting for informal learning and student connection inspired by creativity, discovery, and collaboration. Due to the flexible and informal nature of the makerspace environment, it is an ideal place to build and create social connections between students. Supporting students' social and emotional development is an essential component to creating culturally competent, well-rounded engineers who exhibit a strong sense of belonging in engineering. Funded through the NSF Research Initiation in Engineering Formation (RIEF) program, this project researched the impact of integrating social engagement activities into an academic makerspace on the development of student sense of belonging. The primary research question explored the extent to which participation in the engagement activities leads to an increased sense of belonging for engineering students. Spanning a two-year period, a series 32 of social engagement events were hosted in the engineering department makerspace. The authors collected data about students perceived social belonging in both the makerspace and the department. Students completed two surveys: a pre-survey administered at the beginning of the event and a post-survey administered at the end of the academic year. Findings indicate the social engagement events had a positive impact on the development of student sense of belonging to both the makerspace and the engineering department. These results are encouraging as they suggest that events designed to support the social and emotional development of students can positively impact student sense of belonging to a makerspace environment and, more broadly, to engineering. By creating supportive communities of students built on shared experience and trust, we begin to develop the inclusive communities of learners that is a key component to diversifying pathways to engineering.

Literature Review

Well supported academic makerspaces provide students with open access to resources that help them develop their problem-solving skills, provide opportunities for collaboration, increase self-efficacy, and develop sense of belonging [1] [2]. Sense of belonging generally relates to self-perceptions of fit within a given context and has been well established as a theoretical construct throughout the literature [3] [4]. The context in question can be formal, such as an educational setting or STEM discipline, or informal, such as friendships or affinity groups. The positive impacts of a strong sense of belonging on academic achievement and persistence in STEM majors are well documented [5] [6] [7]. When students interact in positive ways with diverse peers, sense of belonging improves [8]. The term student engagement refers to the extent to which students invest, value, and participate in their educational experience in a meaningful way [8] [9]. The positive outcomes associated with student engagement include increased student achievement, decreased dropout rates, and more positive emotional experiences [9].

Makerspaces and maker-centered learning shows promise for broadening participation, promoting innovation, and increasing STEM identity. Research has shown that participating in academic makerspaces is associated with positive changes in students' design, engineering task, and innovation self-efficacies; motivation; expectations of success; interdisciplinary awareness; and belonging [10] [11] [12]. However, research also shows that makerspaces can be intimidating to new users, leading to feelings associated with a lack of belonging, especially for women and other traditionally marginalized students. Both fear of criticism and fear of failure has led to gender imbalances in makerspace use [13]. Furthermore, recent research has shown that many maker-type environments do not readily support diverse populations [14], create tensions between different student groups [15], and can sometimes lead to a work environment that feels exclusive and unwelcoming [16]. Other research points to gender differences in sense of comfort in makerspaces [17]. Thus, the design of these spaces and events that take place in them must be carefully considered.

Rationale

Western Washington University (WWU) is a public institution with approximately 15,000 full-time undergraduate students, 160 academic programs, and a vibrant campus community. The Engineering & Design Department (ENGD) offers four undergraduate-only programs: Electrical & Computer Engineering (EECE), Manufacturing Engineering (MFGE), Polymer Materials Engineering (PME), and Industrial Design (ID). In this department, students first enroll as pre-majors in the department and then apply to the program, typically in the second year. There are approximately 200 major-level students and 100 pre-major students.

WWU institutional data and department research data show that 1. the percent of women-identified, first-generation, Pell-eligible, and underserved students declines from the pre-majors to the major; 2. there has been a decrease in diversity as the programs have become more competitive; 3. pre-majors, women-identifying, and non-dominate students report a statistically significant lower sense of belonging than their counterparts [18]. In response to these data, the Engineering & Design Department First Year Program (FYP) has recently implemented strategies focused on supporting pre-major students, increasing student sense of belonging, and creating inclusive work environments. Efforts have included updating the first year curriculum to incorporate social justice [19], integrating inclusive practices into the departmental makerspace [20] [21], creating a summer bridge program for engineering students [22], conducting research on impacts of curricular and co-curricular changes on belonging and identity [23] [24] [25] [26], and this project, an National Science Foundation project which seeks to increase student sense of belonging in undergraduate engineering students through the integration of social engagement activities into an academic makerspace [27].

By providing opportunities for students to participate in non-technical activities within a makerspace environment, this project aims to encourage students to come to the makerspace with the sole purpose of connecting with their peers through participating in workshops and events. This, in turn, will introduce students to the makerspace who may not otherwise choose to and/or may be intimidated by the technical components of the space.

Social engagement activities, in this context, are defined as events, projects, and workshops that have a strong emphasis on supporting the social and emotional development of students. To encourage connection with peers, the engagement activities are created, supported, and directed

by team of major-level students (paid employees). The social engagement activities are structured to support students from all backgrounds, prior knowledge levels, and interest areas. Prior work details the social engagement activity development process and summarizes the overall design, participation, perceived participant engagement level, successes, and challenges of the activities [27]. Davishahl & Boklage (2022) found that the social engagement activities were successful from the standpoint of student participation numbers and general level of engagement during the events however, the design and implementation of the events is an important factor to success. To ensure equality of access and to allow for flexibility, the engagement activities must be designed to maximize student ability to participate, regardless of prior knowledge or ability level.

Data Analysis

The primary research question that guided this work was “To what extent does participation in the engagement activities lead to an increased sense of belonging?” All activities followed federal standards for the protection of human subjects in research, including appropriate review by a registered internal review board (IRB).

Spanning a two-year period, a series 32 of social engagement events were hosted in the engineering department makerspace. The authors collected data about students perceived social belonging in both the makerspace and the department. Students completed two surveys: a pre-survey administered at the beginning of the first social event each student attended, and a post-survey administered at the end of the academic year. The survey questions used a 11-point Likert scale ranging from 0 (Strongly Disagree) to 10 (Strongly Agree). The students were asked to rate the extent to which they agree with a series of three questions focused on *department level* belonging and three questions focused on *makerspace* belonging.

Results & Discussion

Student Survey Results

Summary statistics for the quantitative survey questions are summarized in Table 1: Quantitative Survey Results. Average scores for pre- and post- were calculated and data was analyzed using paired sample two-tailed t-tests to determine if survey results in any areas changed significantly between the pre- and post- surveys.

Table 1: Quantitative Survey Results

Question	Pre	Post	P-value
I see myself as PART of the makerspace	6.25	6.73	0.08*
I feel that I am a MEMBER of the makerspace	4.82	6.29	0.04**
I feel a sense of BELONGING to the makerspace	5.71	6.76	0.15
I see myself as PART of the department	6.38	7.00	0.51
I feel that I am a MEMBER of the department	6.25	7.35	0.29
I feel a sense of BELONGING to the department	5.44	6.73	0.08*

* statistically significant at $p \leq 0.1$ level ** statistically significant at the $p \leq 0.05$ level

These findings indicate that the social engagement events impacted student sense of belonging in the makerspace and engineering department. Student data revealed that students felt like a member and part of the engineering makerspace after participation in these events and an explicit sense of belonging in the department.

Table 2: Student Demographics and Belonging Change summarizes the major and demographic information of the students who completed both pre and post surveys. Authors calculated a “belonging change” score which reflects the difference between the students’ pre and post survey scores. Students who are not in the ENGD department showed either neutral/no change or negative change in their sense of belonging in the makerspace. This is in stark contrast to students who are in the ENGD department as they showed either neutral/no change or an increase in makerspace belonging. Data reflecting the departmental sense of belonging is varied. One finding to note is that female and genderqueer ENGD students all indicate positive or neutral/no change belonging change to both the department and the makerspace. These results may suggest that purposefully designed social engagement activities can support engineering students from marginalized identities in engineering departments and makerspaces.

Table 2: Student Demographics and Belonging Change

Student	Major	Gender	Race	Belonging Change	
				Makerspace	Department
A	Non-ENGD	Male	White	0	0
B	Non-ENGD	Genderqueer	White	-2	0
C	Non-ENGD	Female	White	-1	0
D	Non-ENGD	Genderqueer	Hispanic, Latino	-3	5
E	ENGD	Male	White	1	-1
F	ENGD	Male	White	0	1
G	ENGD	Male	White	0	-1
H	ENGD	Male	White	2	0
I	ENGD	Male	White	0	0
J	ENGD	Male	White	2	2
K	ENGD	Male	White	8	6
L	ENGD	Male	Asian	1	1
M	ENGD	Female	Hispanic, Latino	0	0
N	ENGD	Female	White	4	3
O	ENGD	Female	White	3	1
P	ENGD	Genderqueer	Middle Eastern or North African	5	3
Q	ENGD	Female	White	0	1

The survey also included an open-ended prompt “In one word, please define what sense of belonging means to you.” The answers to this question are summarized in Table 3: What does sense of belonging mean to you? Examining the answers to this question helped the researchers understand student perceptions of sense of belonging. Results indicate that, by and large, students relate belonging to feelings of inclusion (feeling wanted, acceptance, togetherness) and

positive emotional states (happiness, comfort, contentment). The researchers interpreted these results as positive perceptions of belongingness.

Table 3: What does sense of belonging mean to you?

Pre-Survey	Post-Survey
-	inclusion
welcoming	inclusion
fitting	welcome
inclusion	Acceptance
content	Comfortable
included	Inclusivity
community	Inclusion
inclusive	welcomed & wanted
happy	Happy
-	comfort
-	togetherness
inclusion	Welcome
feeling wanted	Feeling wanted
smiling	Support
inclusion	Together
Purpose	Inclusivity
home	home

Limitations:

Limitations to consider include the context of the makerspace in an ENGD department at a single university. While the social engagement activities were advertised across campus and various social media mediums; notification of the events was limited. The student response rate to the post-survey was relatively low (n=19), yet the authors believe these findings are the first step in identifying actions makerspace managers can implement to encourage student participation for all students. Additionally, belonging is not a stasis state for individuals and can ebb and flow depending on internal and external contexts (e.g., mental health, current events) and the authors recognize that these surveys were administered at two points in time. Finally, despite the qualitative component of the survey, researchers should not expect students to understand the nuances of belongingness as participant, member, and general sense of belonging. While these limitations should be considered, they should not discourage researchers and facilitators of events in makerspaces to understand the impact of these engagement activities. What is not captured in these results, but was clear from observing and simply being in the space alongside the students, is that these events formed the basis of establishing a community of students, engineers, and makers which the authors believe is essential to contributing to the field of engineering, but more importantly, feeling connected on a human level.

Conclusions

This methodology and findings are unique and exciting to support not only how engineers understand sense of belonging in makerspaces; but also what actions can support sense of

belonging for students, especially those from marginalized populations. This research compliments current research examining student sense of belonging, but rather from recruiting outside of the makerspace [17], participants in this study directly participated in student engagement activities in the space. This paper summarizes how social engagement activities, designed to support the social and emotional development of students, can positively impact student sense of belonging to a makerspace environment and, more broadly, to engineering.

This overall aim of this project was to aid in the development of well-rounded, culturally competent engineers who exhibit a strong sense of belonging in engineering which will ultimately contribute to diversifying the workforce. This study helps to lay the foundation for future research that will inform strategies to create an equitable and inclusive makerspace culture with a focus on better supporting traditionally underrepresented students. Subsequent research will explore how student participation in these types of engagement activities correlate to the development of an inclusive makerspace and engineering education culture.

Acknowledgement – This material is based upon work supported by the National Science Foundation S-STEM program under Grant No. 1834139. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the National Science Foundation.

References

- [1] M. Galaleldin, F. Bouchard, H. Anis and C. Lague, "The impact of makerspaces on engineering education," in *Proceedings of the Canadian Engineering Education Association*, 2017.
- [2] S. Vossoughi, P. Hooper and Escude M, "Making Through the Lens of Culture and Power: Toward Transformative Visions of Educational Equity," *Harvard Educational Review*, vol. 86, no. 2, pp. 206-232, 2016.
- [3] S. Hurtado and D. Carter, "Effects of College Transition and Perceptions of the Campus Racial Climate on Latino College Students' Sense of Belonging," *American Sociological Association*, vol. 70, no. 4, pp. 324-344, 1997.
- [4] K. Osterman, "Students' Need for Belonging in the School Community," *Review of Educational*, vol. 70, no. 3, pp. 232-367, 2000.
- [5] L. Hausmann, J. Schofield and R. Woods, "Sense of Belonging as a Predictor of Intentions to Persist among African American and White First-Year College Students," *Research in Higher Education*, vol. 48, pp. 803-839, 2007.
- [6] E. Seymour and N. M. Hewitt, *Talking about Leaving: Why Undergraduates Leave the Sciences*, Boulder, CO: Westview Press, 1997.

- [7] E. Tate and M. Linn, "How Does Identity Shape the Experiences of Women of Color Engineering Students," *Journal of Science Education and Technology*, vol. 14, no. 5/6, pp. 483-493, 2005.
- [8] J. Fredricks, P. Blumenfeld and A. Paris, "School Engagement: Potential of the Concept, State of the Evidence," *Review of Educational Research*, vol. 74, no. 1, 2004.
- [9] F. Newmann, *Student Engagement and Achievement in American Secondary Schools*, New York, NY, 1992.
- [10] M. E. Andrews, M. Borrego and A. Boklage, "Self-Efficacy and Belonging: The Impact of Makerspaces.," *International Journal of STEM education*, vol. 8, no. 24, 2021.
- [11] E. Hilton, Forest, CR and J. Linsey, "Slaying Dragons: An Empirical Look at the Impact of Academic Makerspaces," in *International Symposium on Academic Makerspaces*, Stanford, CA, 2018.
- [12] L. Rosenbaum and B. Hartmann, "Making Connections: Project Courses Improve Design Self-Efficacy and Interdisciplinary Awareness," in *International Symposium on Academic Makerspaces*, Stanford, CA, 2018.
- [13] V. Bean, N. Farmer and B. Kerr, "An exploration of women's engagement in makerspace.," *Gifted and Talented International*, vol. 30, no. 1, pp. 61-67, 2016.
- [14] A. S. Masters, "How Making and Makerspaces have Contributed to Diversity and Inclusion in Engineering: A [non-traditional] Literature Review," in *American Society of Engineering Education CoNECD - The Collaborative Network for Engineering and Computing Diversity*, Crystal City, VA, 2018.
- [15] S. Vossoughi and B. Bevan, "Making and tinkering: A review of the literature," Commissioned paper for Successful Out-of-School STEM Learning: A Consensus Study, Board of Science Education, National Research Council, Washington, DC., 2014.
- [16] M. Andrews and A. Boklage, "Spaces and Practices within University Makerspaces," *IEEE Frontiers in Education Conference (FIE)*, pp. 1-5, 2023.
- [17] C. Kaat, S. Blair, L. Julie and A. Layton, "Do I Fit In? Examining Student Perceptions of Belonging and Comfort in University Makerspaces," in *International Symposium on Academic Makerspaces*, Pittsburgh, PA, 2023.
- [18] *WWU Institutional Data, Engineering Department*, 2019.
- [19] J. Davishahl, "Centering Social Justice in Engineering: A new course model for first year engineering education," in *American Society of Engineering Education Annual Conference*, Baltimore, MD, 2023.
- [20] J. Davishahl, C. Boland and N. Crow, "Increasing Inclusive Access to Makerspaces using Digital Badges," in *International Symposium on Academic Makerspaces*, Atlanta, GA, 2022.

- [21] J. Davishahl, "Keep it simple, keep it real: Creating Inclusive Makerspace Environments," in *Proceedings of American Society of Engineering Education Collaborative Network for Engineering and Computing Diversity*, 2021.
- [22] J. Davishahl, J. Brobst, S. Alqudah, A. Klein and L. Litzler, "Math to Makerspace: Evolution of a bridge program to support cohort development.," in *Proceedings of American Society of Engineering Education Conference*, Baltimore, MD, 2023.
- [23] J. Brobst, J. Davishahl, L. Litzler, S. Alqudah and A. Klein, "Examining first-year engineering programs' impacts on sense of belonging across gender," in *Proceedings of American Society of Engineering Education Annual Conference*, Baltimore, MD, 2023.
- [24] J. Brobst, E. Litzler, S. Alqudah, R. Barber DeGraaff, J. Davishahl, P. Fizzano, D. Hartenstine and A. Klein, "Developing sense of belonging in isolation: insights from two projects supporting STEM undergraduates," in *American Educational Research Association*, San Diego, CA, 2022.
- [25] J. Brobst, E. Litzler, J. Davishahl, S. Alqudah and A. Klein, "Impacts of supports on student affect in an engineering-focused S-STEM," in *Transforming STEM Higher Education Conference*, 2020.
- [26] J. Davishahl and S. Al-qudah, "Complete Work: Investigation of Sense of Belonging to Engineering in Undergraduate Introductory Classes," in *Annual American Society of Engineering Education Conference and Exposition*, 2020.
- [27] J. Davishahl, A. Boklage and M. Andrews, "Development of Social Engagement Activities to Increase Belonging," in *Proceedings of the 127th American Society of Engineering Education Conference and Exposition*, Minneapolis, MN, 2022.