Investigating Student Experiences of Inclusion and Exclusion to Guide Makerspace Development

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INTRODUCTION

A sense of belonging is vital to the success of engineering students during their academic journey. At the Colorado School of Mines, first year students' design experiences will be held within our new flagship innovation, fabrication, design, & entrepreneurship center (hereafter makerspace). By creating a welcoming and inclusive space that ties deeply into students' first year, we hope to enhance students' sense of engineering identity, improve learning outcomes through greater access to makerspace tools and community, and to increase retention and recruitment rates, particularly for traditionally underserved students.

While a sense of belonging can lead to higher retention and persistence, the feeling of being excluded can lead students to leave STEM majors or drop out of university entirely [1]. Mistakes when setting makerspace culture can be costly in terms of diversity by pushing out students who otherwise are borderline in their perceptions of belonging in STEM programs and institutions.

This work-in-progress paper shares results from the first year of our two-year study. In year one, we focused on collecting data on the experiences on inclusion and exclusion that students face at our institution. This paper provides a preliminary analysis of that initial data and provides suggestions to our makerspace director and other institutional leaders. While we recognize our work will not be complete before making our initial recommendations to the director and student workers in the makerspace, we feel the right time to engage in inclusive community building and norm setting is when a makerspace is first opening. Thus, our initial findings and early-stage recommendations will be shared midway through this study. In year two, we plan to conduct follow up interviews to track the results of our suggested interventions on the makerspace's culture in terms of inclusion and exclusion. We imagine the second round of interviews may also reveal new areas of importance that we may have missed in our initial round of interview collection. Further literature grounding will also occur in year two.

To better understand how to create a welcoming makerspace, and avoid exclusionary practices, a student research team, under the direction of a lead faculty member, collected and analyzed the broad experiences of inclusion and exclusion at our university. This study had a particular focus on the student experiences of non-traditional students, LGBTQ+, underserved minority, women, and students with disabilities but was not exclusive to those categories. The study was also not limited to regular users of existing makerspaces. Our goal was to capture snapshots of the campus experience to better understand how both makerspaces users, and non-users, experienced inclusion and exclusion in and around campus spaces.

After obtaining IRB approval for the study, student researchers collected 26 30–60–minute qualitative interviews during the 2023 Fall semester to understand the students' institution–specific experiences of inclusion and exclusion. Additional interviews with students, faculty and administrators will be conducted during the 2024-25 school year.

During this project, five student research assistants conducted semi-structured interviews with their fellow students. The interview data collected was analyzed and used to help create suggestions for practices that might lead to a diverse and inclusive culture in our new makerspace. By discovering what individual students and stakeholder groups value and expect of

an inclusive makerspace the research team was able provide guidance to campus leaders and the makerspace director to help create a culture where students can learn, grow, socialize, and enhance their engineering identity.

This paper shares the student research team's journey through creating an interview protocol, see the appendix for the complete protocol, conducting interviews, and performing an initial analysis. The work-in-progress version of this paper attempts to engage with some of the work being done at ASEE by others interested in exploring makerspaces, retention, and the impact of identity formation on underrepresented student groups. For the final version after year two of the study, we expect to engage much more deeply with the broader literature on the subject. While the recommendations are site specific to our university, we expect some of the practices to be universally helpful and for the methodology to be useful to anyone interested in better understanding their university's culture.

Previous studies examining makerspaces and their role in inclusion, and exclusion, in universities have found that women, students of color, members of other underrepresented groups, and particularly those with intersectional identities can suffer from feelings of exclusion, bias, and discrimination in university makerspaces [2]. Further, it is noted that in some academic makerspaces, a third or more of students may first interact with the space due to required course activity, return to complete coursework, and are less likely to return if their first visit was for a personal project [3]. At the Colorado School of Mines, all incoming students will interact with the campus makerspace as a course requirement within their first year. Due to this high mandatory engagement with the makerspace, it is vital that the space be welcoming and inclusive to all students regardless of major, interest area, or prior shop experience.

In terms of best practices in opening, operating, and maintaining academic makerspaces, there is a consensus that there is no one-size-fits-all policy for these spaces [4]. In one of the author's experiences, while community is often highlighted as a value important to makerspaces, at conferences like the International Symposium on Academic Makerspaces (ISAM), more of the focus seems on engaging students generally than on ensuring inclusive engagement of students. Similarly, in an author's experience, while machine and shop operational safety is often a focal point of makerspace management discussions, psychological safety sees less engagement.

Our research team was particularly inspired by the approach used in Listening to Makers: Exploring Engineering Student' Recommendations for Creating a Better Makerspace Experience by Jennings et al, 2019. We were deeply impressed with their approach to seeing what students' experiences were in makerspaces and analyzing their experiences with a critical eye towards race, gender, and social experiences [2]. However, we attempted to cast a wider net by interviewing not only students who were users of makerspaces on campus, but also students who chose not to use campus makerspaces. This resulted in an initial focus on understanding our university's students' experiences with regards to inclusion and exclusion much more broadly combined with specific questions about makerspace participation on non-participation. We expected to see similar results to those documented elsewhere, but additionally sought to identify institution-specific examples of spaces, programs, and classes that students describe as inclusionary or exclusionary. The following research questions are investigated in this paper.

RQ1) What do students perceive/experience in terms of inclusion and exclusion at the Colorado School of Mines?

RQ2) How can the experiences of exclusion and inclusion found in our student interviews help inform the director and student leaders within our new makerspace to aid in creating policies and fostering a culture of inclusion while bringing light to exclusionary pressures students feel in other spaces on campus?

RQ3) Which of the policies mentioned above, and to what degree, are effective in fostering a community of inclusion within a makerspace? (Not included in this paper and reliant on post intervention data collected in years two and beyond)

BACKGROUND

The Colorado School of Mines is a mid-sized STEM-focused institution in the Western United States. With approximately 7,500 total students across a variety of engineering and STEM disciplines, it displays a typical gender ratio for undergraduate engineering programs of approximately 35% female and 65% male students. White students make up nearly 67% of the student body and 27% identify as people of color, with the remainder undeclared or identifying as two or more categories [5]. While these demographics are not unusual among engineering colleges more broadly, they do pose challenges at a STEM-focused university where there are no additional majors or colleges beyond engineering, sciences, and business/economics due to the lack of gender and race diversity that may be present in larger, more academically diverse, universities.

Mines only began engaging with makerspaces robustly in 2017 with the opening of the Blaster Factory. What began as a student club turned into a central location on campus for 3D printing, laser cutting, and other hobby-making activities [6]. Additional campus spaces under the makerspace umbrella included a small wood shop and a soft materials lab where first-year design programming took place. All other fabrication shops on campus were departmentally controlled and, even if open more broadly to the student body, poorly advertised as such.

Having opened in February 2024, the Labriola Innovation Hub is the university's new flagship makerspace [7]. With over 35,000 square feet of fabrication, design, and collaboration spaces, it offers a great opportunity for students to learn new skills, practice using state-of-the-art equipment, and complete course-related and personal projects. The space is open to all students, staff, and faculty on campus and integrated into Mines's required first-year engineering design course as well as the senior design course required for over half of the undergraduate students on campus. It currently employs three full-time staff and ~50 student shop assistants. The Innovation Hub uses a "train the trainer" model for teaching students how to teach others to become certified in safely and appropriately using the equipment. Training modules will be developed by student leads for each piece of equipment or space. The other student workers in the space will take the module, learn how to teach it, and then offer lessons on a scheduled or walk-in basis for the rest of campus. With low numbers of full-time staff, this operations model

will require thoughtful training in both machine safety and a culture of inclusivity to ensure students from all backgrounds and identities feel welcome in the space.

METHODS

For this project, five undergraduate students were trained in qualitative data collection and analysis methods. Over the Fall 2023 semester, these students developed an interview protocol (see appendix) and conducted 26 30-60-minute interviews with their fellow students to determine both what their experiences were broadly with inclusion and exclusion at the university, as well as their experiences within the existing maker and shop spaces and within classes that utilize those spaces.

Interview audio recordings were transcribed and coded in an open-ended manner by individual students. Due to time constraints for this conference paper, interrater reliability checking was not completed; however, future analysis will include attention to reliability as well as additional dimensions of the larger project.

Using analysis approaches from Applied Thematic Analysis, coded responses were grouped and analyzed for thematic similarity and representative quotes were identified to be used in an explanatory manner [8]. Selected quotations, and their related themes and elaborations, are provided in the Data and Analysis section that follows.

The discovered themes and examples were then compared to available diversity, equity, and inclusion trainings offered at the university to make suggestions to the director and leaders of the new campus makerspace. The university offers trainings in avoiding microaggressions, gender and sexual orientation allyship, bystander response, and a variety of other DEI related workshops. These workshops are usually utilized by faculty and staff organizations within the university, but it is the research team's hope that making these trainings a mandatory part of student (as well as full time faculty and staff) employee onboarding in the space will reduce instances of bias, discrimination, or exclusion within the makerspace, and the effectiveness of these trainings will be considered in future research.

DATA AND ANALYSIS

Demographics of Interviewees

The demographic breakdown of our 26 interviewees can be seen below.

Gender	**Age**	**Race (self-reported categorization)**
17 identified as female	15 were 18-20 years old	12 reported as White
8 identified as male	8 were 21-23 years old	3 reported as Hispanic
1 identified as non-binary	1 was 31-35 years old	2 reported as White, Hispanic
	2 did not respond to the question	2 reported as Asian
		2 reported as White, Asian
		1 reported as Chinese Asian
		1 reported as African American
		1 reported as Middle Eastern, White
		2 did not respond to the question

In addition to the identities shown above, participants were in some cases members of identity groups they found relevant to their experiences at Mines. These identity categories included, queer, bi-sexual, on the autism spectrum, and religious. While very few interviewees expressed categories of identity beyond race, gender, and age, we recognize that our interviewees also possess often invisible identity traits, which may or may not impact a students' experience of inclusion/exclusion. Interviewees' experiences, intersections, and identities are discussed in greater detail in the paper's analysis section.

In the sub-sections below, themes are discussed with their relevant quotes from the dataset. In lieu of grouping by type of exclusionary experience, i.e. microaggressions, sexism, isolation, etc., the research team instead grouped thematically by the context of the experience. These contextual categories are experiences pertaining to campus culture, student community, student views of upper administration approaches to DEI, physical spaces, and perceptions of staff (both student staff and university staff). These broader thematic areas of analysis allow for a nuanced view of our interview participants' experiences, both positive and negative, on campus in spaces including, but not limited to, makerspaces.

Qualitative Data Analysis by Thematic Area

One rich thematic area focuses on how students perceive the campus culture with regards to inclusion and exclusion. Importantly, interviewed students see campus culture as distinct from student community. We separate the two, campus culture and student community, to also draw attention to the different power structures at play. Campus culture is determined by history, the

faculty and non-student staff, engineering identity more broadly, and attitudes at the university about what defines rigor and high-quality work. Community, explored in greater detail below, is about the connections students make with one another in groups outside of academic hierarchy. In the third section of analysis, we will connect the campus context in terms of culture and student community with specific makerspace-related responses.

Campus Culture

In terms of campus cultures, our interviewees focused on two primary areas. One was the technical nature, and culture, present at a STEM university. The second was their vision of administration efforts towards DEI implementations on campus. They commented on the culture and its effects on feelings of inclusion and exclusion. They discussed how they as students perceive the impacts of DEI efforts, qualities which serve to obfuscate issues of inequality and inequity, and the stress put on them by a perception of "academic rigor" that does not allow for failure or iterative learning. Below, we discuss groupings of quotes to dive deeper into these themes.

Several students linked DEI efforts and the engineering discipline, with one saying, *"There's a large history of depoliticization in college universities and technical universities in general. And I think that because of that there's become this idea that people are stuck in that we're here to, like, collect equations and, like, technical skills and we can do MATLAB and Python and then we walk out with this, like, armful of diverse skills and that's it… that's the reason why people are resistant to DEI because it requires them to acknowledge that they have an impact on society and other people even though you have the title of engineer."* (Female, white)

Further, they saw that depoliticization as a means of hiding the effects of privilege and fitting in with the mold of the "traditional" engineering student. The removal of focus on inequality, inequity, and alternative educational pathways leads to exclusionary pressures on "non-traditional" engineering students, for example, students of color, women, and those who did not receive extensive mathematics and engineering training in high school before entering the university.

"Liberal arts school is more (about how) to find yourself and get opportunities. Whereas (in) a technical university it's like already really hard to get in. and you know what you're getting out of it. You have to know exactly what you're doing. And a lot of people have privilege already to know exactly what they're trying to do because growing up in an environment where it's expected that you know what you're doing." (Male, white)

For example, when it comes to the privilege of technical training in high school, another student stated that *"Mines is definitely more inclusionary of people who have significant competency in quote unquote hard skills. Already like if you come into Mines and you're already, like, a SolidWorks genius, like, you're going to feel very at home… so I think pre-existing technical competency creates a better sense of inclusion for students, maybe there's an exclusion of students who really care but don't necessarily already have the background."* (Female, white)

"A lot of students, like, they come in here with like credits, you know, and they come in here with like, you know, in high school they were doing like all STEM activities. So, like they come in here with prior knowledge, prior experience of like how things operate and you're coming here, you know, bare, you know, with nothing." (Male, Black)

It was also noted that the engineering focus on numbers as the only valid data type also led to feelings of marginalization and tokenization.

"Because we are a technical university, we will take a more technical aspect to improving inclusivity and diversity. I think that we like to pay attention to numbers. That's what engineers do. So, like anytime someone mentions like the 60:40 (male to female) ratio, like, that's exactly what we're focusing on… but the numbers are kind of how we define it in our heads which can lead to assumptions." (Female, white)

"…then they tokenize you. So, it's like they don't actually stand in your corner, but they'll use your photo to be like we're so cool and diverse." (Female, Chinese Asian)

The university culture towards failure further exacerbates the often-hidden inequities and stresses that can lead to feeling left out at a technical university. Despite over 30 years of scholarship exploring how failure can lead to supporting learning outcomes given chances for reflection, iteration, and post-failure educational support [9], students at Mines largely see themselves as facing an institution that does not support failure, reward iterative learning, or allow for support when structural inequalities lead to uneven outcomes.

It *"definitely makes it a lot more stressful, not feeling like I have any like wiggle room to make a mistake. But I would say that's kind of how I feel about all of my classes is that I don't have a lot of wiggle room."* (Male, white)

The lack of support for learning through failure impacts how a student learns/feels about failure within an academic space: *"The reason why I feel it's so hard to fail is because I just don't feel like I can, like, the work is just so hard that I don't feel like I have any room to not be perfect."* (Male, white)

Further, the connection between technical university culture and the perceived impacts of failure can lead to increased anxiety about how the student is perceived more broadly.

"Like as a technical university it's like, yeah, because I feel like, I feel like everybody is so academically inclined here that if you fail a class, you'll probably be judged and you will." (Female, Asian)

The students interviewed recognized this as a missing part of their education leading to a sense of exclusion. Further, they see how failure is often celebrated in a media context, or through the reflections of faculty, but seldom considered when it comes to actual coursework.

"In every single one of my classes, I feel like it's wrong to fail at something. ... I like the idea of Failure Fridays, I'm pretty sure is what it's called, where basically, I'm pretty sure it's the Mines YouTube Channel, they post a video from the staff and they talk about a failure they had and how

they came back from that. That feels nice for, like, moral, but I don't think there's a single class where it's, like, I failed and they were, like, 'oh, that's fine.'" (Female, White)

In the few cases where learning through failure was discussed as well supported at Mines, the students saw it as a deep opportunity for enhanced learning outcomes.

"In Design Engineering, failure is bread and butter," ... "In Grandey (a first-year honors program) and Design Engineering, it feels awesome to fail honestly because you'll fail and then your professor will be like, 'Interesting, so what happened?' and then you get to explain, and then it's not really a grade deduction, which is awesome because it's like leaning into the idea of failure as a way of learning." (Male, white)

Another student connected failure to ambiguity and ability to share saying *"There are no wrong answers, so I guess there is some room to fail because there isn't really a wrong answer all of the time. So, everyone in the class is always just like talking to each other instead of having a right and a wrong answer, it feels like everyone's opinions are accepted whether they're agreed with or not."* (Male, white)

Anxiety and personal preferences can affect how a person feels valued and belonging in certain places: *"I don't think anyone has explicitly made me feel unwelcome, but I'll be at an event or in a class and ... I'll be, like, oh, I'm not doing this well. Like, I'll start getting a little scared and think, I don't belong here because of test grades or because I just feel like I'm not understanding the concept as well as other people."* (Female, white)

Students may also feel less welcome and valued in a classroom or makerspace if they are not academically successful. This anxiety about learning cultures also influences student perception of inclusivity in makerspaces. These spaces are not a place students feel they can fail, something one student connects to inability to learn *"I would say that it's less safe [to fail] because I think that there's a pressure in the design lab and a low tolerance for mistakes in terms of not understanding that people are trying to learn…"* (Female, Hispanic, white)

Feeling isolated or excluded in campus culture was often tied directly to racial minority status.

"So, if you're in a space, right, and you're the only black person in like a group of like maybe 50 people, you know, uh, and you're all, you know, set to do like the same job, you know, being an engineer, that could feel like a form of exclusion. I feel like there's a intelligence exclusion as well. So, if your ideas get excluded because of either your gender, the way you look, um, to know your race, things of that nature, I think that can be, uh, exclusion. And then when it comes to inclusion, I mean just basically, you know, the polar opposite, just feeling like your voice is heard." (Male, Black)

Views of Administration DEI Efforts

In our data, it emerged that students possess strong opinions on the administration's views and implementations of DEI measures on campus. While this was not the primary focus of the study, we include the details we have here as a starting point for deeper conversation about student

perceptions of DEI measures. These perceptions provide valuable insight into how universities might put forward measures for makerspaces, and campus more broadly, in ways that are perceived as more authentic and personal.

Students expressed a variety of perceptions of the university's motivations surrounding DEI programs. One student expressed inclusivity is a priority to the administration, because *"I think they're kind people, and I feel inclusivity comes with being kind"* (Male, white)

Another focused on the power of open discussion about the challenges university student can face: "*...they don't really hide the fact that, like, sexual assault happens or they don't hide the fact that, like, there are alcohol issues for some students. Or like mental health problems. The fact that they kind of advocate for those things that you can fall back onto if something goes wrong has this comforting aspect. So like if I mess up or if someone else messes up and I don't know what to do, that's where I can go."* (Female, white)

This openness of conversation extended to the sense, from students of color, that the university was making strides in terms of DEI measure on campus.

"Now that I've like been in more leadership positions, um, one thing that I've seen is like, it's, I think they're doing better. Um, they have, they're the (DEA) specific, like, I don't know, team at Mines is doing. I think it's improving and like having their voices, having student voices heard when it comes to, you know, making those big decisions." (Male, black)

"I've been able to have like really good conversations with leadership, um, like, administrative leadership with at Mines about, um, like these social situations (inclusion and exclusion). And in a lot of those times they're pretty open-minded, and I think they definitely open the floor to what students want to hear." (Male, Hispanic)

Conversely another student believes *"[the university] is not necessarily coming at inclusivity from, like, an inherently good standpoint, but from, like, it's correct right now in history to be inclusive. And so, we should do that so that people like us and come to this school and give us money."* (Female, white)

An additional perspective reiterated that inclusivity is important to the university from an admission standpoint, once again mentioning the gender ratio on campus: *"everyone is working towards [inclusion], especially when it comes to stuff like looking at admission statistics and demographics, like, they're always saying, like, 'oh we want to improve, like, the variety of backgrounds that we have here' and that's what you always see when applying to colleges and stuff. But I think, like, they're trying to work on the ratio of like women to men… so I feel like it definitely applies to admissions."* (Female, white)

Returning to the sense that the engineering focus on numbers as data, students often feel that the administration increases diverse student populations for the sake of marketing and that the purpose of some DEI efforts are intangible and/or ingenuine, the priorities of the upper-level administration is to align with that of donors and shareholders, minority students may feel tokenized because of the lack of perceived demonstrated and genuine interest in DEI by upper-

level administration. *"I think as a school as a whole we've accepted [DEI], but we haven't embraced it."* (Female, Hispanic, white)

Student Communities

Student-to-student interactions, clubs, Greek life, and extracurriculars like band and sports were all perceived as being student communities. How students supported or rejected one another in these communities reinforce feelings of inclusion or exclusion on campus. The few interviewees with deep experience in makerspaces likewise felt it was a community of its own, though those comments will be explored more fully below in the *Makerspaces* analysis section.

One interviewee clearly described the perceived challenge of community building at Mines along with how student communities exist within the broader campus cultures. This connects well with the perception of low tolerance (socially, academically, and personally) for failure at the university leading to a stronger focus on individual academic achievement over a more holistic community-based learning approach.

"...having a well-rounded engineer and understanding impacts and stakeholders about what projects they're designing is super, super important, but a lot of people think 'we're in a STEM school that doesn't even matter'... but you can't really go through Mines alone. So, some sort of community wherever that comes from I think is super important. But due to our STEM and technical university standing, I feel like that's put even more on a back burner." (Female, Chinese Asian)

Shared values were regularly brought up by our interviewees as ways of describing being part of a community. This could be within an organization, club, hobby, or major.

"Band is really cool because everyone that's in band is there because they want to, they're into music. We're all engineers, but we love music and we're there to play and perform, and it created a really cool environment, ... I did feel really welcomed in the band and music community camps." (Male, white)

"I felt like we had similar passions and that's what really made it feel inclusive because ... I think, like in Design [Engineering], it's like people have a passion for making the world a better place, and it was very inspiring because it was, like, I like engineering because, I want to solve people's problems, but I want to do it in a way that's, like, constructive towards a better society. And I think being around people who share similar values, that's what it is. I think it's that the values are community based." (Female, white)

Unsurprisingly, the focus on shared values serves to both draw individuals into student communities as well as push them out. Without care to what community values are chosen and represented within a student-centric makerspace, there could be inadvertent exclusionary pressures. For example, the sorority system at Mines both serves to engage and support women while also pushing others away from the community.

So, like, I think like the Panhellenic (sorority) community is very, like, oh, like, we're all like kind of suffering in, like, this male dominated environment a little bit. Not to, you know, not suffering, but you know, we're experiencing the same systems acting against us. And I think definitely, like, Panhellenic stuff, like, I'm like, oh, like, we're all in the same boat. We're all just trying to get through this and we are treated in similar ways. And so yeah. I think that community is very, like, I uplifting and, like, you got this girl. (Female, white)

I don't know, sororities, like I know one of my roommates in a sorority, it's, like, generally welcoming but the actual, like, you still have to, like, go through a lot of things just to be considered a member of it. And then there's, like, such rigid rules you have to uphold. And that just, like, that kind of turned me away from even considering being in a sorority even though, like, yeah, socially it's fun, but, like, all these rules you have to follow. And I'm, like, it's just less stress if you have your own group of, like, girlfriends that you rely on. (Female, white)

This focus on community as a potential added stressor or rule laden barrier to entry could be a potential area to consider when crafting a makerspace community. Several students also reflected that racial differences led to feelings of isolation and how specific and intentional student organizations focused on multicultural engineering could help.

Yeah, definitely. I remember this one really important day during my college experience where I was walking back to my dorm and I heard some Puerto Rican music by Bad Bunny. And I remember I was just like, what? Like, who's playing that music? And I remember finding SHPE (Society of Hispanic Professional Engineers), um, at MEP (Multicultural Engineering Program) and so they were handing out, like, goodie bags. And so, I remember coming out of that physics class being, like, wow, like, I'm not smart enough to be here. I remember calling my mom, like, mom, what am I doing here? I think I made the wrong choice. There's nobody that even looks like me. And then, so that day I was like walking with my head down and then I, like, heard the music and I was, like, what? Like, yay, this is exactly what I needed. They handed me like a little goodie bag of, like, Mexican candies. (Male, Hispanic, white)

"Imposter syndrome is all over regardless of race. But especially with minorities, especially at this school because, you know, there's not a lot of us, and especially when it comes to black people, since we're like, I think still less than 1% of the (campus) population. So yeah, they just, it's hard to feel welcome. But being a part of NSBE and going to that national convention really made me feel proud to be a black engineer." (Male, Black)

In the case of those with intersectional identities, students commented on how even what should be supportive organizations could be unwelcoming and difficult to navigate.

It's sometimes difficult to find space and connect with people in that capacity. Um, like, uh, I want it to be a part of oSTEM (LGBTQ+ STEM organization), but I think that in the, like, this isn't an oSTEM problem, it's more of just like a general queer community problem is that it can

sometimes be dominated, like, it's still, like, white dominated. So, like, having intersectionalities or multiple identities, um, sometimes make it so that, like, you wanna be included in both communities, but sometimes it feels like you're involved in none. (Male, Hispanic, queer)

Students talked quite a bit about the spaces they felt community in and why they felt it strongly in those spaces. Whether the space was a retreat where a creative could escape from the overwhelming focus on STEM, a place with multicultural aspects that countered the racial homogeneity of campus more broadly, or simply an escape from the heart of campus itself, having a place away from the academic, primarily male and white, and anxiety inducing sense of urgency was vital to students' sense of well-being.

"but ,like, home is, like, where I can, like, kind of resort back to what I know and what I like and what I'm good at. And that's, like, being creative. And so, like, on the honors house, ...when I just, like, came across that aspect of the school, it would, it's the critical reason why I'm still here. 'cause I think if it wasn't here, I don't think I'd be here." (Female, white)

"I definitely think MEP is like the physical space of MEP. Just having, like, I think I feel very welcome there. I'll talk like specifically about, like appearance wise, it just feels very homey with, like, all of the paintings and the decorations. Um, just the multicultural aspect. It's, it's a vibe that you can't really feel across all other aspects of campus." (Male, Hispanic, queer)

"I don't know, I kind of, like, like, also the sorority houses are kind of, like, a little bit offset from campus. So, like, breaks between classes, I can go up there and just, like, chill out and it's, like, you know, like, the idea of like a third space, right?" (Female, white)

While the above examples help to showcase how students at Mines think about their student community interactions, it is worth noting that they also recognize how much of that stems from specific actions on the part of the campus administration. The links between campus culture and student community building are clear in the first year or. two of a student's time on campus.

In response to the interview question "tell me about a time at Mines where you felt really welcomed", one student relied. "*At Mines? Oh boy. I'd have to say <laugh> crazy enough. Like the M climb (a community-building hike and celebration at the beginning of the school year) and all of those events that they were having before the school year started, those were definitely nice. They were a little overwhelming—I'm not gonna lie—but I think that the fact that they were trying so hard to get us to build a community felt welcoming. Because they were trying to point out that, like, everybody feels like a bit of an imposter. There was the imposter syndrome going on, and the fact that they were pushing that and saying, like, Hey, just try and meet people because nobody knows anybody. The fact that they were trying to do that I think was really nice and it felt inclusive. And then I also think, and um, I also think that the amount of clubs that we have here that are targeted towards almost every demographic that you can think of is also really powerful to their statements of trying to show inclusion. I don't know how successful they've been*

personally, but I know that just the fact that they have those and are trying shows something is nice." (Female, white)

Finally, in terms of community at Mines, nearly every non-male identifying interviewee discussed how they felt underrepresented in classes, clubs, events, and even public spaces. These instances ranged from being ignored while sitting at a table where they were the only woman to being crowded out of a highway by men taking up the entire space without noticing they were trying to pass to being actively told they don't belong in STEM. Much like the other examples of feeling excluded at Mines, this was expressed more strongly in cases of intersectional identities.

Makerspaces and experiences of inclusion and exclusion

Interviewees' specific experiences with makerspaces varied dramatically, from initial interest and an immediate feeling of belonging to being ignored or even in one case dismissively pushed off to another staff member as a nuisance. Unsurprisingly, these experiences connect deeply to the previous categories of campus culture and student community. Those that fit the more "traditional" image of engineering, in terms of demographics and prior technical experience, tended to feel more welcomed. Those with underrepresented racial, cultural, sexual orientation, or disciplinary backgrounds, as well as those with intersectional STEM minority identities or lower self-perceived technical ability often felt unwelcome in existing (pre-Spring 2024) makerspaces. Below, we present some of these student experiences.

Students are often drawn to, and interested in, makerspaces on campus. They imagine these spaces as locations to build personal and class projects, get inspired for creative exploration, and to learn new technologies.

"Okay. I was kind of just there to browse and look at what other people have been doing, which was also really fascinating. Yeah. Um, because it was really colorful. Oh my gosh. It's crazy correlation with color. Um, it was very colorful and I was looking at all the things that other people had done, and it was kind of inspiring my own creativity. But the thing is, I have no background experience with 3D printing, so I didn't actually do anything while I was there. I was just kind of looking. Okay. I didn't really talk to anybody, so I'm sure I could have asked what to do. I just, yeah. I don't know. I just wanted to check it out." (Female, white)

This vision of a makerspace as a colorful, exciting, and inspiring place to learn can rapidly be either reinforced or rejected depending largely on the student staff attitudes within the makerspace. Even if a makerspace is physically welcoming, staff interactions can quickly change student perceptions of that makerspace. Far and away the most common experience that turned people away from makerspaces were student staff interactions that ranged from being overly controlling when helping with a project to apathy and deeply dismissing a fellow student's right to be in the space.

(After approaching a student worker in the makerspace) "*Hey, I have this thing I need to print, and I've never printed anything here before. Like, can you help me out? And then the student worker who helped me was like, oh yeah, for sure. And then just kind of, like, drove on my computer themselves, which I was, like, okay, cool. Like ,it's nice that, like, you're, you're doing this for me. But also like,, I would, I would like to learn, I didn't say that out loud, but it was in my, in my head. Um, but then the second time I was like, Hey, can you show me? Like, can you teach me how to do, like, be more explicit? Like, I, my goal isn't just to get this printed but also to gain the autonomy to do it on my own."* (Female, white)

"I felt like I was an inconvenience to a lot of them, in a way that by me being there, they were not getting to do something else they'd rather do" and "*There's no accountability either from my understanding of making sure that people are being kind and inclusive. They're very full and they're rude about it or like no one is really willing to help. I've had very negative experiences there."* (Female, Hispanic, white)

In addition to the overall attitude presented by student workers, another student noted that the way in which they were referred to made the space feel incredibly uninviting.

"So, I came in, I said, Hey, I have a, a very funky thing I need to, I need to make, um, and someone said someone was, was very clearly free and not really doing anything, um, and said, 'oh, can someone else take this?' ***And not even "they", they said "this"****. They said, 'can someone else take this?' Not, 'Hey, can someone else help this person? ' Or, 'Hey, what's your name?' Just, 'Hey, can someone else take this?' And I was like, Ooh. I immediately, you feel like more of a, a thing than a person and more of a, a burden than anything else. Um, so I think, yeah, that was definitely <laugh>. Yeah, just not a good, not a good feeling. And I think more the, the terms and and phrases they were using just kind of dehumanizes people."* (White, female, queer)

In contrast, some interviewees discussed their positive experiences in makerspaces and shops across campus.

"One time I wanted to print like this resin miniature for like Dungeons and Dragons, right? And um, I was helped out by someone there, and they were like extremely helpful, showed me how to, like, properly install the software, how to properly load the file and configure it for specifically resin printing just because it's a little bit more involved than normal film and dispensing ones. So, Blaster Design Factory I think is a great place (and) very inclusive. You've got just people just chilling there and then if you need, like, it's also a study space as well. So, it's like if you need help you can definitely ask them and, like, the student workers, they will definitely help you." (Female, white)

"Yeah. I feel like, uh, Digger Design Lab, um, I've, I've definitely lucked out whenever I have because there's usually TAs in there and usually TAs for the wood shop. Um, and when I go in,

they're like, Hey, what can I help you with? And that is the, the phrasing I need to automatically feel welcome in a space." (Female, white)

"The machine shop downstairs in Brown, I haven't really spent enough time in there to get to know the vibe. Um, but I like the room from what I can, from what I've been told. The room is really nice and it's, uh, really, it's a great space, like socially wise. Um, and the people that work there are super duper nice to talk to, because they really want to help people. Um, and they're fountains of knowledge, especially in machining. 'cause that's something that if you don't know how to do learning, it's really difficult. Um, and they're really good at teaching, which is nice." (Male, white)

So I think, I think whenever people can like, implement themselves into like a design situation, um, they tend to be pretty passionate about it and are willing to like create and invite, um, to really anybody. And I think that's pretty cool, at least in my experiences. (Male, Hispanic)

Students who found the spaces welcoming similarly enjoyed the short workshop approach used for teaching tools, safety, and operations within many of our makerspaces and shops on campus.

"This is something cool I've always wanted to learn. They're going to have like a one day workshop for an hour. I can show up, learn a little bit of a new skill, and then I can go on my own and use this skill in a personal project or a class project or otherwise. I really like the idea of workshops; I think they're very, very useful and it's something we don't see a lot of. ... I think it's cool that sometimes we're having those workshops, other times we're learning them from other students. Again, that student to student is really, really powerful, especially in the workshop and learning new skills space. It's a lot easier to learn something from a peer than I feel like it is to learn from a professor, because I feel like there's a little bit of a disconnect, especially in that like age gap and weird hierarchical situation." (Male, white)

While our data is limited in terms of responses from students with underrepresented identities, there is enough to take seriously the possibility that many students of color, underrepresented STEM minorities, and those with intersectional identities are being left out when it comes to feeling invited and welcome in these valuable campus resources. In part two of this study, we will attempt to gain additional data to explore this area of potential concern.

DISCUSSION AND RECCOMMENDATIONS

In the introduction to this paper, we discuss how we expected our findings to be similar to those reported elsewhere, and indeed that is what we discovered. The feelings of isolation experienced by underrepresented groups in STEM, the increased challenges across almost all metrics when students experience intersectional identities, and the anxiety over failure and omni-present experience of imposter syndrome among STEM students are all well known [1]. However, we also discovered a keen awareness among our students about the challenges found in these issues. They reflected deeply on how they experienced inclusion and exclusion; how the engineering vision of what constitutes as data that made them feel, literally, like just another number rather

than a whole and complete person; and how race, gender, and prior skill acquisition can lead to visible and unseen inequities. What follows is a series of recommendations based on our interview results and the resources that exist here at our specific institution. While the names of trainings, organizations, and resources may differ at other campuses, we imagine the explanations will allow for similar decision making beyond our institutional environment. In 2024-2025, we will follow up with additional interviews—with students, student makerspace staff, administrators, and full-time makerspace staff—to assess the impacts of these recommendations. The full paper including those details will be shared at a future ASEE national conference.

Among our interviewees, the single most often cited challenge to engaging with makerspaces was unresponsive or hostile/dismissive interactions with student workers at the makerspace. While it's worth noting that among the regular users of campus makerspaces the staff were perceived as friendly and helpful, if often overworked in some of the other campus makerspaces, many more potential makerspace users were likely excluded from participation who would have been interested in learning and building within those spaces.

Our team looked at the list of available trainings through our Diversity, Inclusion, & Access (DI&A) team at Mines. [10] According to our interview data it is vital that student workers are trained in best practices with regards to diversity and inclusion. We strongly recommend that the following courses, delivered by the DI&A team, be required for every makerspaces student worker and staff leadership position.

- Allies for Gender Equity
- Minimizing Microaggressions
- Understanding Unconscious Bias

These trainings help participants grapple with the nuances of interpersonal interactions, including being ignored, assumed technically incompetent, or dehumanized. It would also be helpful if students getting trained in the makerspace more broadly were also required to at least participate in an online module covering these topics as part of the introduction to the space or general safety training for the space.

The full-time staff should also engage in regular and open discussions about race, gender, and class inequities within Mines and engineering more broadly to help students contextualize their role in the educational institution. Students deeply appreciate the chance to learn from one another, and the effects of a negative peer learning experience can be profound. Providing context for one's role as a student worker in the broader university culture can be invaluable for providing quality peer learning opportunities.

"I think it's cool when you enter a room or you enter a space and there's a student teaching another student, um, that adds a little more to the phrase, "At Mines, we climb together." Um, 'cause then everyone is helping everyone and it's, it's really nice… It's the transmission of knowledge essentially between, laterally and not hierarchical, I guess is the term. Not just from professor to student, but from student to student."

It is also worth encouraging, and training, student workers to actively greet students coming to the makerspace. In many cases, our interviewees noted that they don't engage with campus makerspaces due to simply feeling ignored or unwelcome in the space. Simple student worker training on how to effectively operate in what is, in many ways, a customer service role could dramatically improve how inclusive campus makerspaces are perceived.

"I mean… if there's a space that, like, you walk in and people, like, automatically, like, open and maybe either greeting you and, like, you know, are open to help you…if I'm in this space and I need help, here's where I can go and here's, like, I can feel confident that this help will be able to help me regardless of my understanding, you know, or my education regarding, like, you know, whatever I'm trying to work with. I think that's really welcoming." (Male, Black)

Further, many of the negative interactions within the makerspaces at Mines seem to stem from two factors. One, if student workers are engaging in their duties as volunteers or poorly paid members of a club, they are less likely to engage in a reliably professional manner. While this can be problematic in an entirely optional campus space, it is potentially disastrous in a space in which all students are required to go as part of their introductory courses. A second, related issue that can lead to exclusionary pressures is the formation of cliques within the student worker group in these spaces. Much like the sorority examples given by our interviewees, a group that is very tightly knit can provide support for its members but be seen as exclusionary to those outside of the group.

The above issues suggest that any large campus makerspace that is entwined with required coursework should be staffed by well-trained, reasonably compensated, student workers. Further, managing the culture on the student worker side will require regular check-ins and reminders from full-time, non-student staff. Student workers in these spaces will certainly form friendships, but it would be valuable to provide training on how to make sure visiting students are fully engaged with and not ignored or excluded by student staff who might otherwise develop an us-versus-them attitude.

As the structure of the newest makerspace on campus continues to develop, continuous engagement and focus on preventing clique formation or other exclusionary pressures could be integrated into leadership and student leader opportunities through the use of a committee or dedicated DEI individual. By doing so DEI can always be thought of and addressed from beginning to end of new projects and updates. Regular reinforcement training could also be useful in addition to training at onboarding.

In terms of staffing, both representation and hiring individuals with a focus on inclusivity could make an enormous difference. Full-time staff hires should emphasize the need for cultural sensitivity and a focus on DEI. Particularly for students who feel isolated due to race, cultural background, gender, or sexual orientation/expression, seeing a face that is recognizable as part of your community can immediately make a place feel more welcoming. Part of student hiring should likely focus on diversity and interest in learning and helping others over pre-existing technical skills.

"A space that is a service arm of the school should not be entirely student run, and it should not be funded by a club." (Non-binary, white)

Finally, and perhaps most importantly, our interviewees' experiences led us to see inclusivity as an ongoing series of actions rather than a single state of being. Campus makerspaces should actively invite the students from underrepresented groups to their spaces. To avoid even the appearance of tokenization, it's important to include the student groups and organizations on campus in the planning and execution of events and activities from the beginning. For example, we would recommend that our makerspace staff reach out directly to the following organizations, and likely others, to begin by inviting those who are most likely to experience exclusion within our institution.

- Multicultural Engineering Program (MEP) and their supported organizations
    - American Indian Science and Engineering Society (AISES)
    - Kickstart
    - National Society of Black Engineers (NSBE)
    - Out in Science, Technology, Engineering, and Mathematics (OSTEM)
    - Society of Asian Scientists and Engineers (SASE)
    - Society of Hispanic Professional Engineers (SHPE)
- The Society for Women in Engineering (SWE)

Students want to bring their authentic selves and all the layers of their identity to participate in makerspaces and shops across campus. They should be encouraged and invited to do so.

"So SHPE (Society of Hispanic Professional Engineers) has been a really great, um, connector for me. I think it has allowed me to connect, like, STEM to my Hispanic background, which I feel like there has, like, there was never really any sort of connection between, like, STEM and my heritage. Um, and so I think, like, SHPE has allowed me to find, like, connections between, like, the culture that my family practices and, like, the history that we have and seeing how I can use, like, STEM as, like, a catalyst to take my family into different parts of STEM and, like, develop, um, I guess just also encourage education also in my family." (Male, Hispanic)

We look forward to gathering additional data from interviews and observations of activity in the new makerspace and expanding on our findings and suggestions in the 2024-25 academic year.

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Appendix

Interview Protocol – Experiences of Inclusion and Exclusion at ANONYMIZED

Setting: In order to conduct the interview, we'll meet somewhere where the interviewee feels comfortable and where we have privacy, such as an office or conference room. I will position myself so I can make eye contact with the interviewee and set an audio recording device between the two of us.

Before the Interview Begins: Introduce the interviewee to the informed consent form and allow them to read and sign the form. Answer any questions they may have related to the study or consent form.

"Thank you for agreeing to participate in our research project. I'm going to ask you some questions to help guide a conversation between us. The questions are there to help guide the conversation, but if you feel there is something not addressed in a question that's important, please just start talking about it. Is it OK if I record the audio for our conversation?"

[Begin Recording (Assuming consent to be recorded is given. Otherwise take notes during the interview.)]

"Hi, I'm going to ask you some questions about your experiences in academic spaces and with inclusion and exclusion more broadly. There are no wrong answers to these questions, we just want to better understand your experiences. You can ignore any question you don't feel comfortable answering and you can stop this interview at any time you desire. Do you have any questions before we get started?"

[wait for questions]

"Great, let's get started."

Interview Protocol

For each question below, I will be looking for an answer in the form of a story or longer than a sentence description. I will ask sub-questions to follow up or dig deeper as needed. If questions are answered in another part of the interview, I may change the order or skip over questions already answered.

Question	**Purpose of question**
1. To get warmed up here, let me ask a couple questions about your situation at Mines and your background. What year and major are you here at Mines?	Warmup and Demographics
2. Great! And, if you don't mind, what is your race, gender, and age?	Demographics

a. (If very comfortable answering) Are there other identities or group affiliations you'd like to share?	
3. Real quick, how would you define inclusion and exclusion? There's no right or wrong answer here, I'm just trying to understand how you think about these terms.	Definitions
4. Thanks, that will help us better understand your experiences here. To start off, can you tell me about a time you felt really welcomed in an academic or school related space? a. Was it a person who did something to make you feel welcomed? Could you describe to me how they made you feel like you belonged in that space? b. What did it feel like to be welcomed or belong in that space? c. Can you think of any parts of the physical space that helped you feel welcomed there?	Inclusion
5. When you think about Mines, what is the space you've felt most welcomed in here? a. Can you tell me about the last time you felt totally welcomed and included here at Mines? b. What made you feel great about that space? Was it people, architecture, signage, etc.? c. Do you frequently return to that space and if so have you brought others with you? Did they have the same experience as you did? d. Are there specific identity spaces that you feel comfortable in?	Local inclusion
6. Thanks for sharing that. I'd like to hear a bit about what strikes you as inclusive when you enter a new space. What are some "green flags" or things that you see or experience that immediately make you feel more welcome?	General inclusion
7. From your experience, how does Mines, the administration, faculty, staff, and students, view inclusion? a. If you were to name specific values or goals of the university, what would those be? b. Do you think the groups mentioned before are equally on board with their vision of and push towards inclusion?	School of Mines culture of inclusion

c. Are there any specific policies here that are important to you in terms of fostering an inclusive atmosphere?	
8. One more questions on the inclusive side of things, what is your favorite space at Mines, academic or not, and why?	Local inclusion
9. Thanks again for the thoughtful responses. I'd like to switch gears a little bit and explore some of the more negative experiences you may have had. Just as a reminder, if you don't feel comfortable answering a question, you don't have to. Thinking broadly about times you've felt excluded, what are some "red flags" that when you see or experience in a space, immediately make you feel unwelcome or excluded? A. Can you tell me about the last time you had immediate bad vibes about a space? What were the clues? B. Can you tell me about a social situation that felt off or discouraged you from wanting to revisit a space? C. Are there ways that people make you feel unwelcome? Can you tell me a little more about the specifics of how?	General exclusion
10. Can you tell me about a time you felt really excluded or unwanted in an academic setting? This can be either her at Mines or in other situations. A. Was it something someone did or didn't do that made it feel that way? B. Were there physical aspects of the space that contributed to your feeling of exclusion? C. Can you tell me about an experience of that kind of exclusion that happened in non-academic spaces?	Academic exclusion
11. I'd like to home in a bit on Mines more specifically. Have you experienced a place, class, or extracurricular experience here that made you feel excluded? Can you tell me more about that experience? a. Can you tell me about a time where a class or space made you feel unwelcome or interfered with your learning by being exclusionary? b. Has there been a time here where somebody attempted to be inclusive , but it had the opposite affect?	Mines exclusion

12. Can you tell me what your least favorite place is at Mines and why it makes you feel that way?	Mines spaces - exclusion
13. Thanks for sharing your experiences with exclusion and inclusion. For the next few questions, I'd like to focus more specifically on makerspaces and making at Mines. Have you been to any of the Mines Makerspaces like the Blaster Factory, Digger Design, or Machine shops? Can you tell me about how your experiences there were inclusionary or exclusionary? A. Were your experiences in that space different if it was for a class or for a personal project? B. Were there ways that people acted that made the space feel that way for you? C. Were there physical aspects of the space that contributed to that experience?	Makerspaces at Mines
14. I'd like to talk now about the kinds of learning cultures you may have experienced, either here at Mines or elsewhere. Can you give me an example of a space or class where you felt it was safe to fail? a. How did people behave in that situation? And how did that add to your feeling of comfort? b. Were there physical aspects that helped with the feeling of safety?	
15. Lastly, I just have a couple questions about your perceptions of Mines, and learning more generally. First, how much of your learning do you want to be self-directed? a. What does self-directed learning mean to you? b. Can you tell me about a time a professor had you learn something on your own? How did you feel about that? c. Do you prefer to learn a new skill through a workshop or project or by getting introduced to a technical skill and then allowed to make it up as you go?	
16. After all this discussion of inclusivity and exclusivity, I was wondering if you had any thoughts on your experiences in first year design, Cornerstone or Honors, and how they felt inclusive or exclusive to you?	

17. (If interviewee is a senior) Are you taking Capstone or have you done Field Session? If so, how did that course make you feel in terms of exclusion or inclusion?	
18. Lastly, Mines is considered a technical university, what has this meant to you in terms of exclusion and inclusion as it relates to the culture of a technical university?	
19. Thank you so much for your time! Before we wrap up, is there anything else you would like to add?	

“Again, thank you so much for participating in our study. We’ll email you soon with your gift certificate. If you have any questions for us, or have any additional experiences or feedback you’d like to share. Please don’t hesitate to email us. Thanks again, and have a wonderful day!”

[end recording on devices and collect any signed materials]