Examining Gender Inclusivity through Sense of Belonging in a Summer Research Experiences for Undergraduates (REU) Program at a Large Research University

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Abstract

This mixed-methods study describes the examination of women students' sense of belonging in the Summer 2022 NSF-funded Research Experiences for Undergraduates (REU) program in a chemical engineering department at a large, Research 1 (R1) university. In addition to learning technical research skills through the REU program, REU administrators hoped to promote and assess a host of educational and psychosocial skills, including the interest and motivation for participating in undergraduate research, the likelihood of attending graduate school, engineering growth mindset, sense of belonging, and creative identity. To measure any potential changes in participants in these areas from before to after participating in the REU, evaluators conducted both pre- and post-surveys and individual interviews with the participants. With the mentioned host of learning outcomes associated with participating in the REU, there was a direct benefit of increased learning outcomes to those who participated in the REU. The sense of belonging (Belongingness) scale utilized in the post-survey was analyzed to determine how men and women identifying students experienced belongingness during the REU program. Belongingness was analyzed due to its close association to student retention and persistence, with a greater sense of belonging contributing to higher retention rates. This study assessed specifically women identifying students' experiences and used men students as a comparison group in the quantitative survey section only. The individual, qualitative interviews focused only on the women-identifying students' interview data. Results showed that women students experienced a lower rate of belongingness than their men student counterparts, based both on the Belongingness scale data and the coded interview data.

Introduction

The historical gender disparity in engineering education and industry is well documented [1]. According to the 2015 American Association of University Women (AAUW) research report *Solving the Equation: The Variables for Women's Success in Engineering & Computing*, in engineering and computer science (two of the highest-paid STEM fields), only 21% and 19% of college majors were women [2]. Additionally, though women graduate college at a higher rate than men, women currently represent only 18-19% of STEM graduates [3]. Women are as capable as men in engineering majors, but women are facing barriers to retention and persistence that their men counterparts do not face. Research on sense of belonging has shown that women who experience a high sense of belonging are more likely to persist through their undergraduate academic programs [4]. Productive research experiences for undergraduates, such as the REU program, can successfully promote sense of belonging, retention, and persistence for students in engineering majors [5]. Therefore, to examine women students' sense of belonging in the 10-week Summer REU program, belongingness of undergraduate women and men participants were measured and compared.

Definitions

For the purposes of this paper, the term "women" is defined as those assigned as female at birth, and/or who identify as women for their gender identity. For this paper, the term women includes women from all racial/ethnic backgrounds. The term "Women of Color" (WOC) is used to describe women who are Black, Indigenous, Latina, Asian, and/or Pacific Islander [6]. The acronym BIWOC (Black, Indigenous, Women of Color) was avoided specifically because it leaves out Latina, Asian women, and Pacific Islanders; whom literature has shown have additional institutional barriers to success in engineering majors than White women [6]. The term White is capitalized to recognize it as a racial identity, as noted by Lori Davis-Patton in her work "Reimagining Whiteness in the Struggle for Racial Equity" [7]. Having those definitions in mind, race was not a top identity for examination in this study. The main identity of focus in this study was gender. Throughout this study, participants are referred to by their reported gender identities, which were "women" and "men," rather than their given sex of "female" or "male." In the literature review section, the terms "female" and "male" were used in congruence with specific studies cited to match the terminologies they utilized.

Literature Review

Undergraduate Research

REU programs provide participants with valuable experiences that supplement their traditional engineering coursework [5]. REU programs provide students with opportunities to gain real-world, hands-on experiences working in labs with other researchers and help students to develop research skills and a deeper understanding of the research process. These opportunities can be incredibly effective, particularly in the encouragement of students to attend graduate school or otherwise further pursue careers in STEM fields [8], [9]. Hence, REU programs have been promoted in recent years as a method of creating a sustainable pathway to graduate school [9].

Literature shows that undergraduate research is strongly associated with improvement of the undergraduate education experience [10], [11]. Specifically, participation in undergraduate research decreases attrition rates [12] and increases rates of graduate education [13] for all students, particularly underrepresented and minoritized students. In addition, undergraduate research scholarship is related to the attainment of research skills [10], [14] and to improved persistence to the undergraduate degree [12]. Participation in undergraduate research can also impact the selection of a STEM career [15]. While there are a host of advantages associated with undergraduate research, there are also challenges faced by summer REU program participants. Student participants oftentimes need to relocate to the REU home institution for the summer, which requires students to adjust and adapt at the beginning of the program. Furthermore, relocation in combination with the short time frame of the REU program (typically 10 weeks) makes it difficult for students to have extended engagement in the summer research project. Thus, to help to promote a sense of belonging in students it is important for programs to help students to quickly adjust to the program and to build upon their identities as researchers [7].

Sense of Belonging

This study utilizes Strayhorn's [4] definition of sense of belonging, which refers to a feeling of mattering or being connected and can be seen as a reflection of the supports that exist within a given context. According to Strayhorn [4], a student's sense of belonging has been found to be related to the retention, specifically, of women students majoring in STEM fields. Literature focusing on sense of belonging for women engineering majors has shown that women feel a lesser sense of belongingness than their men counterparts, contributing to a lower rate of retention for women in engineering majors than peers who identify as men [6], [16]. This section highlights three barriers to sense of belonging: negative faculty interactions, negative peer interactions, and stereotype threat.

Though it has clearly been established that sense of belonging is an important factor in retaining women undergraduate engineering students, there are some potential barriers that have been documented to prevent students from experiencing belongingness. Blair et al. found that faculty have the ability to positively or negatively impact women STEM majors' success [17]. Upon studying faculty in a variety of STEM programs, researchers identified three-primary positions related to how faculty members approach the idea of gender equity: gender blindness, gender acknowledgement, and gender intervention [17]. The findings suggest that most faculty members adopt the positions of gender blindness and gender acknowledgement, which do not allow faculty members to actively disrupt gender inequity [17]. Instead, these faculty members were noted as not acknowledging gender inequity in STEM majors, while also viewing it as an external problem unable to be disrupted by their roles as faculty members [17]. Some of the few faculty members who adopted the position of gender intervention were able to disrupt gender inequity, while others often used tactics insufficient to disrupt gender inequity in their classrooms [17].

Women faculty members were also noted as no more or less likely to promote gender equity than their men counterparts, as marginalized faculty "socialized for success" may create patterns of inequality [17]. Blair et al.'s study showed that STEM faculty members were not equipped to help disrupt current patterns of gender inequalities in STEM majors [17]. In relation to the Summer 2022 REU, we used interviews with women-identifying students to examine whether faculty and graduate student mentor interactions contributed to or took away from a sense of belonging in the Summer REU. Not only do negative student/faculty relationships play a role in determining the success of women STEM majors, but also women STEM major's positive or negative interactions with their men-identifying peers.

Another barrier to success that women majoring in STEM fields experience is negative men-peer interactions. Negative interactions with men peers can create an undesirable learning environment and undermine women's confidence, leading to a higher rate of attrition from STEM majors by women [18]. Grunspan et al. showed that men students were more likely to hold a bias in ranking their male peers as more knowledgeable of course material than their female peers and overestimating their male peers' GPAs, while underestimating the GPAs of their female peers [18]. Female STEM majors, on the other hand, ranked both male and female peers equitably and accurately with GPA [18]. In every classroom studied, the most "renowned" students were also male [18]. Women students in the Summer 2022 REU had ample time for

peer interaction during their 10-week REU program experience. The survey and interviews used in this study sought to gain a better understanding of how these peer interactions impacted students' sense of belonging in the research program.

The impact and threat of sexist behavior towards women can also be explained through a term called "stereotype threat." According to Spencer et al., "when women perform math, unlike men, they risk being judged by the negative stereotype that women have weaker math ability. We call this predicament stereotype threat…" (p. 4) [19]. Stereotype threat suggests that the worry or thought of perceived negative stereotypes negatively impacts women's academic performance in STEM courses [19], [20]. Another study showed women who experienced sexist behavior from their men classmates were significantly more likely to perform poorly on an engineering test than women who experience non-sexist behavior [21]. Environments high in sexist behavior put women more at risk for performing poorly and dropping out of STEM majors. However, helping students achieve individuation (listing special interests and describing positive and negative aspects about oneself) has proven to help reduce stereotype threat [21]. Thus, there are likely approaches that can be taken by REU-hosting institutions to ensure the summer research experiences are inclusive and create a more equitable environment thereby allowing for positive experiences for all students participating, regardless of gender identity.

Having an understanding of what contributes to barriers to belongingness has helped inform the scope and data analysis of this project. In summary, the three barriers to belonging discussed were faculty interaction with women students, negative interactions with men-identifying peers, and stereotype threat.

Research Statement

While the literature abounds with studies evaluating the impact of varying REU programs on student participants, less attention has been placed on evaluating specifically the experiences of women REU participants. It is important to ensure that these experiences are inclusive and contribute to positive experiences for all students, including women students. The research questions for this study seek to investigate: (1) How was belongingness in the Summer 2022 REU program experienced differently by women and men identifying students? (2) How did mentor and peer interactions impact feelings of belongingness among women-identifying students?

Methods

Researcher Positionality

Though many have played a role in the development of the Summer 2022 REU program, the positionality of the two-lead authors, who took the main role in creating and analyzing the results for this study, will be discussed in detail.

The two-lead authors consisted of two-graduate students at a large, R1 university. Both researchers are first-generation college students. The first author identifies as a White woman, and the second author as a Chicano man. The woman researcher has a background in studying varying equity issues in higher education and gender disparity in STEM majors; and the man

researcher has a background in mechanical engineering and engineering education and is studying Diversity, Equity, & Inclusion issues in engineering, specifically at the graduate level. The second author held an outsider perspective in terms of gender identity.

Decisions about how to analyze the quantitative data were made through the lens of the White woman researcher, while coding decisions and the interview analysis were carried out mainly by the Chicano man researcher. Though interview participants were from multiple ethnic/racial backgrounds and institutional types, their responses were interpreted by researchers from a historically White, R1 institution. To implement a rigorous and trustworthy research study, mechanisms of trustworthiness were established [22]. Throughout the process, though each author had their own lead analysis, the authors worked together to analyze the data to identify and define emergent themes, and co-construct interpretations and implications.

The next two authors were faculty members in the College of Engineering at the same institution and provided supervision in the evaluation and writing of the paper. The next two authors were the lead PIs for the Summer 2022 REU program. They were both professors in the Chemical Engineering department at the institution. They helped to provide meaningful context for the REU program studied in this paper.

Data & Instrument

This mixed-methods study first uses quantitative survey data from the Belongingness scale collected via the post-survey to compare the measured Belongingness scores between man and woman-identifying students. After that, the study takes a more in-depth look at individual women's REU experiences related to belongingness through coding the individual interview data collected. The data reported here was from a larger research project focused on the assessment of the Summer 2022 Chemical Engineering REU program. During the summer of 2022, assessment data were collected from participating undergraduate students in the forms of pre- and post-survey assessments, as well as post-individual qualitative interviews. The Belongingness scale survey was only included in the post-survey. The goal for this study was to develop an understanding of the sense of belonging experienced by women students in the Summer 2022 REU program, both in comparison to their men peers (survey analysis) and through their individual experiences (individual interview analysis). The same women who participated in the Belongingness survey were also the participants in the individual interviews (though less students were interviewed than who took part in the survey).

Data & Instrument: Belongingness Survey Data

Using Qualtrics, participating undergraduate students completed both pre- and post-surveys designed to assess several constructs related to their REU experiences. The pre-survey was administered one week prior to the start of the REU program and remained open through the first week of the 10-week program. The post-survey was administered during the final week of the Summer 2022 REU program. The Belongingness scale was a subset of the larger post-survey given to participants after their REU experience. The data gathered from the 20 participants from the Belongingness survey subset was put into a datasheet in SPSS. As indicated in Table 1 (below), the 6-question scale utilized a 7-point Likert scale (Strongly Disagree, Disagree,

Somewhat Disagree, Neither Agree nor Disagree, Somewhat Agree, Agree, Strongly Agree). The Belongingness scale was adopted from the *General Belongingness Scale (GBS)* by Malone et al. [23]. For the belongingness scale, a reliability test was run using Cronbach's alpha and a high reliability score of 0.952 was found for the six-items. The six-questions for the scale were:

> *"Indicate the extent to which you agree or disagree with each of the following statements:*
> *1. When I am with other people in the research group, I feel included;*
> *2. I have close bonds with the professor, mentors, and peers in the research group;*
> *3. I feel accepted by others in the research group;*
> *4. I have a sense of belonging to the research group;*
> *5. I have space to talk when we interact in the research group;*
> *6. I feel connected with others in the research group."*

Participants

The population of focus was undergraduate women who participated in the Summer 2022 REU program at a large, R1 university. Twenty students completed the REU program surveys. Nine participants were undergraduate students enrolled in the home institution. Eleven students were supported by NSF funds and came to the REU site from other undergraduate institutions for the 10-week summer program. For the purposes of the surveys, Hispanic or Latino/a was defined as "a person of Cuban, Mexican, Puerto Rican, South or Central American, or other Spanish culture or origin, regardless of race." The question gathering racial identity defined American Indian or Alaska Native as "a person having origins in any of the original peoples of North or South American (including Central America), and who maintains tribal affiliation or community attachment;" Asian as "a person having origins in any of the original peoples of the Far East, Southeast Asia, or the Indian subcontinent, including for example, Cambodia, China, India, Japan, Korea, Malaysia, Pakistan, the Philippine Islands, Thailand, or Vietnam;" Black or African American as "a person having origins in any of the black racial groups of Africa;" and White as "a person having origins in any of the original peoples of Europe, the Middle East, or North Africa." The institutional type is based on the Carnegie Classification system. Demographics of participants are summarized in Table 1 (below). Additionally, the demographic breakdown of women-identifying participants is shown in Table 2.

Table 1: Demographic Information of Participants in the REU Program

Number of Participants	% Women	% UR*	Carnegie classification of home institution % R1 / D-PU / M1, M2, M3*	Class standing for Fall 2022 % 2 / 3 / 4 / 5*
20	45	35	70 / 5 / 25	20 / 35 / 40 / 5

*UR = Under-Represented ethnic/racial group in engineering (Hispanic or Latino, American Indian or Alaska Native, or Black/African American)
*Carnegie classification system- R1: Doctoral Universities – Very high research activity; D-PU: Doctoral/Professional Universities = M1: Master's Colleges and Universities – Larger programs; M2: Master's Colleges and Universities – Medium programs; M3: Master's Colleges and Universities – Smaller programs.
*Class standing = 2: Second year; 3: Third year; 4: Fourth year; 5: Fifth year or higher.

Table 2: Demographic Information of Women Participants in the REU Program

Number of Participants	% Women	% UR*	Carnegie classification of home institution % R1 / D-PU / M1, M2, M3*	Class standing for Fall 2022 % 2 / 3 / 4 / 5*
9	100	56	44 / 12 / 44	45 / 22 / 33 / 0

*UR = Under-Represented ethnic/racial group in engineering (Hispanic or Latino, American Indian or Alaska Native, or Black/African American)
*Carnegie classification system = R1: Doctoral Universities – Very high research activity; D-PU: Doctoral/Professional Universities = M1: Master's Colleges and Universities – Larger programs; M2: Master's Colleges and Universities – Medium programs; M3: Master's Colleges and Universities – Smaller programs.
*Class standing = 2: Second year; 3: Third year; 4: Fourth year; 5: Fifth year or higher.

Data & Instrument: Individual Interviews

Participant Selection & Recruitment:

Eleven-total (five-men and six-women) NSF-funded REU students participated in individual interviews and shared their experiences in the program. All student participants were provided with the project description and informed of confidentiality guidelines. This study utilized interviews only from the six-total women participants who were interviewed. All individual interview participants answered the demographic question, and all described themselves as either men or women. The demographic breakdown of the interview participants that identified as women is shown below (Table 3).

Table 3: Demographic Information for Women Interview Participants

Number of Participants	% Women	% UR*	Carnegie classification of home institution % R1 / D-PU / M1, M2, M3 *	Class standing for Fall 2022 % 2 / 3 / 4 / 5*
6	100	50	17 / 17 / 66	17 / 33 / 50 / 0

*UR = Under-Represented ethnic/racial group in engineering (Hispanic or Latino, American Indian or Alaska Native, or Black or African American)
*Carnegie classification system = R1: Doctoral Universities – Very high research activity; D-PU: Doctoral/Professional Universities = M1: Master's Colleges and Universities – Larger programs; M2: Master's Colleges and Universities – Medium programs; M3: Master's Colleges and Universities – Smaller programs.
*Class standing = 2: Second year; 3: Third year; 4: Fourth year; 5: Fifth year or higher.

Data Collection:

The interviews that were taken as part of the larger study took approximately 60 minutes and followed a semi-structured approach. Questions from the original interview protocol focused on 1) *Motivations for participating in the REU*, 2) *Conceptions of research*, 3) *Impact the REU had on future career and educational goals*, 4) *Perceived gains from the REU*, 5) *Experience with workshops*, 6) *Experience in their research community/group*, and 7) *Possible areas for REU improvements*. The interviews were semi-structured allowing for multiple follow-up questions from the interviewer to help explore the participant responses.

This study focused specifically on the students' sense of belonging in their research community/group. Protocol questions surrounding these experiences included: "*Did you feel that*

you were a part of a research community when you arrived at the large R1 university? Why or why not? Were you able to establish a peer group and make friends while at the large R1 university? Did you feel like you had a community of peers in the REU program? Explain."

Data Analysis (analytic approach):

The interviews were recorded and transcribed using a commercial transcription service. Interview data were analyzed using thematic analysis [24]. The women students' transcripts were read while listening to the interviews to account for any errors in the transcription. Each individual transcript was coded using an iterative/inductive approach [25] to identify major themes. Coding focused on the semantic content of the interview excerpts, that is, focusing on the explicit meanings of the data. Once all transcripts had been coded, categories with many excerpts were further coded to identify smaller grain-sized themes. The themes were discussed between the first and second authors, and a common thematization was agreed upon. Table 3 (below) shows a summary of codes and themes from the interviews.

Table 3: Summary of relevant codes and corresponding themes

Code	Definition	Theme
Research Community	Students discuss working in a lab or conducting research.	i. Learning support ii. Sense of belonging
Research Mentors	Students discuss interactions with their peer mentors.	i. Supportive & positive ii. Guidance & advice
Peer Community	Students discuss relationships with other REU participants	i. Appreciative & enjoyable ii. Close relationships

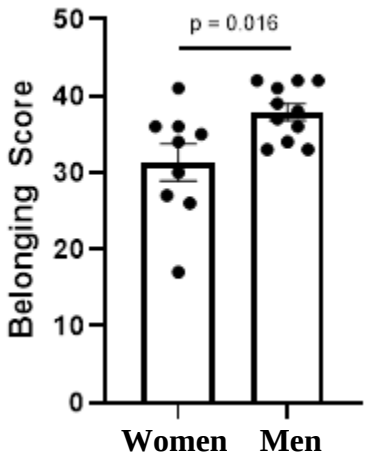
Results & Findings

Belongingness Survey Results

Responses from the men and women-identifying participants of the belongingness scale were analyzed and compared as shown in the box plot, Figure 1 (below). The mean score of the belongingness scale data for men participants was 37.91 out of a possible total score of 42, and for women participants the mean score was 31.33 out of a possible total score of 42. In Figure 1, below, the columns are mean ± standard error of the mean. Dots are individual scores of students on the belongingness scale.

The **minimum** score for participants was 17, scored by one woman identifying student; the **maximum** score was 42, scored by three students who identify as men.

Figure 1: Box Plot of Belonging Score by Gender Identity



An independent samples t-test (two-sided) was used to compare the belongingness scores of the men and women participants, and assumptions of equal variances were met (Levene's test of equal variances, F=3.921, *p=0.063*).

The results of the independent t-test suggest that there is a significant difference in the average belonginess scores between men and women-identifying students (t=2.669, df=18, *p=0.016*). This result suggests that students identifying as women experienced a *significantly lower* sense of belongingness than men students in the Summer 2022 REU.

Individual Interview Findings

Research Community

To examine the impact of the research community on sense of belongingness, students were asked about their experiences working in a lab and with a research team (graduate student mentor, faculty mentor, other students in the lab), and they reported that either all or someone in the research team had a positive impact on them. They mentioned how the faculty or graduate students in the same group provided valuable information on graduate school life and on conducting research. Additionally, two students Clara and Sarah (pseudonyms used to protect the identity of the participants) described how they made connections to other people in the research group and participants in the REU program, and how those social connections made their experience gratifying:

> *"If I'm literally just standing on my counter and* ***I look lost for a second like I'm looking around or something, I'll have them-- 'Do you need anything? Is anything okay?' and I love that."*** (Clara)

> *"...actually my research group, they would go out for coffee breaks a couple of times a week, and they would always invite the undergrads and be like, "hey, we're going to get*

coffee", or we had a postdoc who got a new job and moved away, and all the undergrads were invited to going away lunch. ***So I do feel like the PI and graduate students do their best to make sure we felt involved in part of the group****."* (Sarah)

When asked if they felt they were part of the research community/group there was a shift from not feeling a sense of belongingness, to finding ways to find belongingness and community. For example, Elena and Scarlett describe how this shift occurred. Though Elena did not find a sense of belonging in her own research lab with her own PI, as the program progressed, she was able to find community with other undergraduate students in a neighboring lab. Scarlett described feeling intimidated and like "she was just there" until she began doing more in the lab:

"So I definitely didn't feel that sense of community at the beginning*. But then we also collaborated with [another faculty/lab]. And their team works in the same lab, so we run into them sometimes. We share equipment. And even my grad student, they have an office. And it's a shared space between grad students and undergraduates. And I feel like even though we weren't in the same-- we didn't have the same PI, we all talk. We all discuss our research, to the point where sometimes they'd be doing something and they'd ask-- it was really funny. I feel like they just****-- I feel like it was more involved-- I don't know if it's a community per se, but I would say so. Actually, yeah. It is a community of research,*** *yeah. But at first, I want to say no, and then I was like--once I got to know everybody, I'm like, "Okay, yeah."* (Elena)

"I think when I arrived, it was definitely very intimidating. *And I didn't really feel a part of the community until I started in the lab more and I started talking to people more. Because when I wasn't getting to know others, it just kind of felt like I was just there. But* ***once I started talking, getting to know people, and doing more in the lab, I definitely felt like I belong."*** (Scarlett)

Research Mentoring

To gain a better understand on the impact of mentor-mentee interactions on student's sense of belongingness, students were asked to describe their graduate mentor and how the mentor-mentee relationship went. Five of the participants (all except for one student, Sarah), reported having great regard for their mentors and reported that they were very *supportive*. In the following quotes, students reflected how they thought about their mentors and why they thought their mentors were supportive:

"She gave me some insight into what being a grad student was like. ***She would give me some literature papers, and I would ask her questions, or when doing the experiments, I asked her questions about the results or what exactly was happening,*** *because I wouldn't understand why this happened instead of something else.* ***She also tried to include me in the lab meetings that her lab group would have, and invited me to conferences or meetings*** *which gave me some insight into the different fields and projects."* (Juliett)

"I thought he was a very good mentor. ***What I liked is that before letting me go into the lab, he had me read papers for me to understand the project so that things would make sense when I started working on experiments****. And throughout the summer, he made his expectations clear for what I needed to be doing either in the lab or out of the lab and if I had questions about anything,* ***he was always very available for me*** *to ask, either questions about specific things that I was doing in lab or questions about concepts that I was reading about literature."* (Scarlett)

"But yeah, she's been really great with the giving me work to do. ***I guess kind of like having realistic expectations of what I can or can't do and how much I can get done or I can't get done. And, I mean, any questions that I have she has been super helpful****. Even with now the presentations and the poster, she's been a lot of help to make sure that my presentation just goes as well as it can."* (Vivian)

Unfortunately, Sarah had a different experience than others, with the mentor not providing much guidance. She described her experience with her mentor as if the mentor was "breaking someone down."

"I haven't had the best experience with my grad student personally. It's just been very disorganized, very, very little communication. *So there was honestly, the first couple of weeks, he'd ask me, like, 'Hey, can you come in at this time?' And then he would show up hours later, and I couldn't reach him. And I'd be like, 'Hey, I'm at the lab. Is there anything I can do?' And it just kind of felt like wasting my time and wasting his. It could be productive hours, but it wasn't. And there's also been a couple of incidents where I'll get a result he doesn't like, and instead of being like, 'Oh, okay. It's research. That happens,' it's kind of like, 'Well, did you do that right? Are you sure you know how to use that equipment?'* ***So it's not very encouraging. And it's kind of just like-- it's like breaking someone down.*** *And it's research. All the other professions are like, 'Yeah. It happens. You get results you don't like.' And so instead of just embracing that and let's try again next time, it's like, '****Well, I don't think you did that right. I wasn't watching you. I wasn't hovering' to-- just between the lack of communication and I never know where it is, and just like that-- it's been kind of rough."***

However, luckily, other undergraduate and graduate students in the lab provided help. These other students in the lab made the experience enjoyable for this student. This case is reflected in the following quote.

"There's several other members of the research team. And I have no issues with them. ***They're great. If something goes wrong and my grad mentor wasn't there, they would kind of take me under their wing and be like, "This is what went wrong. Let me help you. Let me help you set this up." And they would really make sure to get me***

going...*There's several undergrads in my lab. And all of the grad students have undergrads right now.* ***But they've definitely stepped up for me, I'd say.****"*

Peer Community

Because interactions with peers have been previously shown to impact women students' sense of belongingness in STEM [18], students were asked about their interactions outside the lab and their relationships with other REU students in the program. All students mentioned they had an enjoyable and appreciative experience. Students noted doing things both in small groups and large groups, and both experiences being enjoyable. One student, Sarah, highlighted spending time with other women, noting that she is close with "two of the other girls" in her program. The following quotes reflect these positive interactions with other peers in the program.

> ***"We talk about our research. I feel like it's good to compare. We didn't talk that much about our technical part but what was our schedule, relationship with our PIs, our grad students and other undergraduates.*** *It was really interesting, and I feel like when we had meetings of everybody, the improv, we got to know more people, and we went to the movie theater, hike and did small activities. We had a group chat which is fun."* (Elena)

> *"I'm not really a social person back home. I tend to isolate. I live by myself. I'm one of those people that class ends, and I leave as fast as possible to go back to my place. But here I thought, you know what, new setting, let's change a little bit. And I did make friends. I was, 'I'm never coming back to [city of the R1 university], there's no reason for me to come back here'.* ***But now I have people telling me, 'Like hey, you should totally come to a football game.' And I'm like, 'We'll see.' If the flights are cheap enough, I might come back."*** (Clara)

> *"Yeah, we've done some things with a* ***larger group*** *that has been a mix of REUs or fellowships, just various people that we know over the summer. And then we've also done some things with* ***just myself and my roommates*** *or ourselves and our friends who live close by. But yeah, we see everybody a lot."* (Vivian)

> *"Yeah, so I go to the gym every night with* ***two of the other girls*** *in our REU program.* ***We hang out all the time. We do stuff. There's big groups of us that go hiking on the weekends or at the lakes or just find random little things that we all can do as a group****. So, yeah, I do really feel like I was able to make friends here." (Sarah)*

Discussion & Implications

The Belongingness survey results, collected in the post-survey, showed a statistically significant difference in the way belonging was experienced between men and women identifying students. Belongingness was experienced at a *significantly lower* rate by women than

the men students who attended the same Summer 2022 REU program. These results indicate that there is room for improvement in supporting a sense of belonging in women participants.

The individual interview results gave a more in-depth look at the women's experiences, which may help to explain why they experienced a less positive sense of belongingness as compared to the men students. Questions regarding the Research Community showed that the women students did not experience a sense of inclusion when they first arrived at their REU program. Several noted that after talking to more people, or meeting in large groups, they started to feel a stronger sense of belonging. These findings suggest that more work is needed in supporting a sense of belonging for women participants in comparison to men participants, especially at the beginning of the program, in the summer research program. Moving forward, it may be beneficial to have more icebreakers for students, team-building events, or large group activities at the very beginning of the program to help the students build rapport and foster a sense of belongingness when they initially arrive.

The Research Mentoring findings also showed room for improvement in future REUs. In one interview, a student alarmingly reported it appeared her graduate mentor was "breaking someone down," and that the mentor used accusatory and condescending language such as "well I don't think you did that right," and "are you sure you know how to use that equipment?" REU leaders could help ensure mentors are adequately fit and ready to provide a more inclusive experience by providing them with leadership and inclusion training prior to the start of the REU program. The mentors may benefit from training in growth mindset, team building, or group management to help them oversee their research groups more effectively and in a more inclusive way.

The Peer Community findings showed the most positive results of the three-coded sections. Participants overwhelmingly reported positive peer interactions. Positive peer interaction is something that was facilitated very well in the Summer 2022 REU, which can be noted as a positive aspect in current program practices that should be continued moving forward. Initiatives REU leaders and faculty mentors can continue to pursue are group social activities for the students both within the overall REU program and within and between research groups. Many of the women students noted the importance of the group socials that were included within the REU program in their development of peer and lab group belongingness.

In addition to gender identity, REU participants also reported racial/ethnic identity within surveys. While the sample size may not be large enough to analyze the intersection of gender and race (e.g., compare data collected from WOC to White women), findings on women as a gender cannot be extrapolated to women from all identity groups. This is an especially critical point when considering what inclusivity means to women from differing, intersectional identity groups [26].

Future Research

Within the existing Summer 2022 REU data, further analysis could be conducted on the other sections of the post-survey to compare the scores of men and women identifying participants. While our analyses of previous cohorts of REU students have shown no gender

differences in student gains in research-based experience and skills during the REU program [27], it would be interesting to further examine whether correlations exist between student learning gains from research experiences with a student's sense of belonging. By further analyzing the additional sections of the survey based on the reported participant sex, more information can be gathered on whether correlations exist between a student's sense of belonging and growth mindset, scientific identity, self-efficacy, and likelihood of graduate school. REU belongingness survey data could also be analyzed by racial/ethnic identity, first-generation status, and other relevant demographic information.

Future research on students' sense of belonging in REU programs could also be conducted at different institutional types in addition to the R1 university highlighted in this study. Also, future research could employ a longitudinal study that investigates the long-term impact on women students participating in an REU program. For example, is there any impact from their REU experience on women students after they graduate in pursing graduate work or careers in engineering? Further, future research should investigate any possible differential effects of being mentored by two or more graduate student mentors, and investigate the link between women students' reported experiences, mentors' reported experiences, and faculty's reported experiences. Whether or not student, mentor, and/or faculty perceptions align could provide critical insight into the REU program, and further explain the experiences of REU participants. Finally, future research could investigate the effects of a students' year in their undergraduate program on their sense of belonging. Students further along in a STEM program may experience differences in their sense of belonging than students just starting their undergraduate education. These additional areas for investigation were beyond the scope of the current study and would likely require a larger sample size than was available in this study.

Limitations

A limitation of this study was the small sample size for the survey data. Though the sample size was small, there was great reliability found in the data. The sample size for the interview portion was also small, so caution should be taken in generalizing the results of this study to REU participants at all institutions, as institutions hosting REU programs can differ in size, research emphasis, and other factors. Furthermore, the interviews from the men students were not analyzed or discussed in this study, so that leaves room for future evaluation of the Summer 2022 REU program. The women's interviews were able to provide a better context and understanding of the belongingness experienced by the women-identifying participants, but without analysis of the men-student interviews, the study does not give further insight into how belongingness was experienced differently for the men and women participants. A way to expand this study would be to add the Belongingness scale to the pre-survey. Adding the Belongingness scale to the pre-survey could allow administrators to collect Belongingness data from the very beginning of the process; from recruitment to the application process, for the Summer REU. If the Belongingness scale is added to the pre-survey, the study could expand to measure any potential belongingness gains by the participants.

Another limitation was in the demographic data collected from the participants. In the questions about race, students were limited to choose from pre-labeled options describing race, and "multi-racial" was not included as an option. It is again important to note that this study

focuses on one specific REU program at a large, R1 university, so caution should be taken in generalizing results to other contexts.

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