First-Generation Undergraduate Women and Intersectional Obstacles to Pursuing Post-Baccalaureate Computing Degrees

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***Abstract*—The number of first-generation women college students pursuing graduate-level research in computer science (CS) and engineering is chronically low compared to men. This study uses Rodriguez & Lehman's (2017) intersectional computing identity theory to analyze pre- and post-survey data collected during three years of a weekend-long all-women and non-binary computing research workshop. We explore the role that systemic factors play in the underrepresentation of first-generation women in graduate-level computing research and investigate how the weekend-long research experience impacted participants' computing identities in a research context. Wilcoxon rank sum tests revealed that first-generation women express lower comfort levels to complete research in the future compared to continuing generation women ($p = 0.017$). However, there was no significant difference between first-generation and continuing generation participants' interest to do research. Survey data also revealed that the majority of participants benefited from the workshop and found all-women and nonbinary teams more encouraging than traditional, male-dominated computing spaces. Findings indicate that first-generation women are more likely to have experiences in computing that lower their confidence to complete research compared to continuing generation women. However, they also reveal that research workshops have the potential to support students' intersectional computing identities and challenge systemic barriers that lower student interest and confidence in computing graduate programs. In order to close the gender gap in graduate-level computing programs, institutions of higher education should consider hosting research workshops that simultaneously provide research experiences for undergraduates (REU) and support the intersectional computing identities of students most underrepresented in the field.**

Keywords—Undergraduate Students, Computing Research, First-Generation Students, Gender, Intersectionality, Research Experiences for Undergraduates (REU)

I. Background

Although the proportion of women holding doctorate degrees in mathematics or computer science increased from 16% in 1993 to 26% in 2015, women's numbers in graduate-level computer science (CS) and engineering are increasing at lower rates compared to their male counterparts [24]. Gender discrepancies in graduate-level fields like computer science and engineering are even more pronounced when looking at race. The number of computer and information science bachelor's degrees awarded to Black, Latina, and Native American women fell by nearly 40% over the past decade, meaning that the graduate applicant pool for this student population significantly declined as well [27]. However, current scholarship tends to overlook how first-generation college student status impacts these numbers and the complex gendered and racialized experiences first-generation women endure throughout their computing education. More research is needed to explore the intersectional experiences of first-generation women in computing rather than separate their experiences by solely gender or race [13][28]. This paper focuses on the intersectional experiences of undergraduate first-generation women in order to understand why they continue to be underrepresented in computing graduate programs.

A. Intersectional Computing Identities

Reference [28] claims that it is important to understand why women and other underrepresented groups in computing (e.g., first-generation undergraduate women) find it difficult to identify as computer scientists in order to increase diversity in computing fields. Building on the seminal work of [7], the authors outline how the structure of the computing field along with already existing forms of intersectional oppression contribute to the development of unique intersecting computing identities that differ from other science, technology, engineering or mathematics (STEM)-related identities. As a result, students with intersectional identities may experience the computing environment through various lenses related to their gender, race, and/or socioeconomic status, and, depending on how people perceive these identities, may experience marginalizing and compounding forms of oppression that impact their persistence in computing and their desire to pursue graduate studies. Given this framework, first-generation women in particular may be subjected to various unique forms of oppression related to their gender, racial, ethnic, and generational status while pursuing their computing degrees.

First-generation women majoring in computing have unique experiences compared to continuing generation women that may make it more difficult for them to persist in STEM. Research shows that generation status negatively predicts STEM degree completion and persistence and can therefore influence the number of first-generation women pursuing

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STEM graduate degrees [2]. This could be due to the fact that first-generation students, in general, tend to lack adequate access to economic resources needed to succeed in college (e.g., laptops) and encounter more obstacles that compromise their academic success [2][25][32]. Additionally, the collaborative values that first-generation students often uphold frequently conflict with the competitive culture of STEM courses and lead to higher levels of imposter syndrome compared to continuing generation students [5].

First-generation women must also navigate societal and cultural factors such as inadequate exposure to computing and gender stereotypes from a young age as a result of oppressive societal practices tied to their intersectional identities as women and first-generation students. For example, girls often lack meaningful access to CS and engineering opportunities during their K-12 education [12][31][37]. First-generation students in particular are even less likely to have taken core classes in math and science needed to enroll in many STEM majors and therefore initially enter college underprepared to pursue STEM majors [1]. In addition to receiving little opportunity to explore computing, girls are also subjected to racial and gender-based stereotypes within the computing field that reinforce and maintain exclusionary practices [14][28].

The compounding effects of limited exposure to CS and systemic biases in computing can follow first-generation women into higher education and affect their enrollment in graduate school. Undergraduate women majoring in CS tend to report lower levels of CS self-efficacy and CS identity compared to men and are less likely to persist in the major [8][23]. When looking at first-generation women, self-efficacy, sense of belonging, and persistence in computing is even lower [3]. Black, Latinx, and Native American women are also less likely to major in computing compared to White and Asian women regardless of prior experience with computing [9]. This means that first-generation women and women who identify as Black, Latinx and/or Native American experience additional levels of oppression and discouragement in the computing field compared to White continuing generation women [27]. Isolation and exclusion in computing is therefore contingent on contextual and intersectional experiences that may lead to the underrepresentation of first-generation women in computing graduate programs [6].

The organizational structures of CS and engineering departments can also reinforce biases towards first generation women that lower their persistence and desire to pursue computing graduate programs [4][26]. Many undergraduate women with various racial and socioeconomic backgrounds have expressed that their CS programs exposed them to hostile computing classroom environments and harmful stereotypes that uphold institutional racism and sexism [37]. Moreover, first-generation undergraduate women report significantly less interactions with instructors than men and continuing generation women [3][15]. Despite these findings, institutional and cultural change within CS departments is slow-moving due to low faculty buy-in and limited resources and/or funding [30]. As a result, first-generation women must build their computing identities and interest in graduate school in unsupportive and discouraging environments [28].

B. Workshops and Mentoring Programs

One promising way to address the underrepresentation of first-generation women in computing research is to create mentoring programs or workshops that allow these students to learn more about the research process. Undergraduate students may have the agency to individually explore and experience computing, but structural inequalities can negatively influence their computing identity development [28]. Workshops can help women identify more strongly with the computing field [10][33] and introduce them to role-models who are enthusiastic, supportive, and compassionate [10]. Research shows that women are less likely to have access to important forms of social capital that help them to develop the network they need to apply to graduate school [21]. Therefore, workshops could potentially provide supportive social networks within the research community that first-generation women need to apply to graduate school.

Workshops that emphasize mentoring and community development create collaborative spaces where students can feel more connected to the computing and research communities [10][35]. The Affinity Research Group Model (ARG) [10] proposes that peer and faculty interactions (external experiences) greatly impact students' computing research identities. Workshops are considered one of four necessary practices of effective undergraduate research education (in addition to annual orientations with an emphasis on team building, intentional project management with established goals and objectives, and regular group meetings for additional research practice) [10]. The ARG model aligns with similar arguments made by [28] regarding the crucial role peers and faculty play in computing identity development. In the ARG model, research workshops can help create high levels of student connectedness around graduate-level computing research, potentially provide an encouraging base for first-generation women to develop the confidence needed to pursue computing research, and open access to critical research experiences for undergraduates (REU) [35].

II. The Tech + Research Workshop

Tech + Research is a 3-day workshop that occurs concurrently with Technica. Technica is the world's largest all-women and non-binary hackathon event hosted by a large Mid-Atlantic university in the United States. The Tech + Research weekend event typically begins on a Friday and ends on a Sunday during the fall semester (either in October or November). Technica participants have the option to be placed in the General, Hardware, or Research track during the weekend event. Each track includes its own unique requirements for the hackathon. Tech + Research is the formal name of the Research track of Technica.

Any Technica participant who is a current undergraduate student majoring in a computing field (computer science, engineering, information technology, mathematics, and/or statistics) at any 2- or 4-year institution can apply to participate in the Tech + Research workshop. Applicants are also accepted to participate in the program based on the following criteria: they identify as a woman or non-binary student of color, they are a first-generation college student, or they indicate that they

have limited access to research opportunities at their institution.

Following the ARG framework [10], the overall goal of Tech + Research is to provide undergraduate women and non-binary students an opportunity to engage in a unique social experience that helps them to build relationships with peers and faculty in computing, engage in graduate-level research, learn directly from researchers in the field, and begin to answer complex research questions related to computing. By the end of the workshop, all participants present their methods, data, results, and findings to the Technica community. The social networks and knowledge gained during the Tech + Research workshop have the potential to create a sustainable community that the participating students can learn and access resources from as they develop an interest in graduate-level computing research.

Tech + Research is separated into four components: student kickoff and community building, research bootcamp, research work time, and final presentations. On the first day of Tech + Research, all participants attend a "research bootcamp" led by a professor from the Computer Science Department at the host university. There are seven main components of the research bootcamp: 1) What is (CS) research?— including an example research problem and an overview of CS research areas, 2) Empirical research example — a guest speaker will use their research as a concrete example of how to ask research questions and answer them through data collection and analysis (this addresses undergraduates' initial misconceptions that CS research is strictly theory-based), 3) Ethics in CS research — definition, history, a brief overview of the IRB process, and examples of ethical quandaries in CS research, 4) Grad school 101 — what a PhD entails, its benefits, and how to have a successful application, 5) A graduate student panel, where the students share their current work and why they decided to go to graduate school, 6) Analyzing data — brief overview of data analysis, with hands-on exercises, and 7) Guest speaker professors discuss their research. The research bootcamp is an important time for Tech + Research participants to learn more about CS research and what it is like to be a graduate student.

After the research bootcamp, Tech + Research participants spend the majority of the workshop (approximately two days) in groups of 4-6 participants and gain hands-on experience performing research in a hackathon-style fashion. Each group is led by a faculty member from the host university and their supporting graduate students. Projects either focus on computer science, engineering, or data science concepts and are small research projects related to larger active research projects at the university. Each weekend workshop supports between seven and eleven projects. Participants have the option to rank their top project choices based on their personal interests prior to the start of the workshop. Tech + Research organizers then finalize the group placements. Given the diverse range of project topics, the specific tools and coding languages used for each project vary. During the hands-on research work time, each group works together to broadly answer a larger research question.

III. Study Overview

In this paper, we take an intersectional approach to investigate how first-generation undergraduate students navigate the computing community and how their experiences influence their intent to enroll in a computing graduate program. Using pre- and post-survey data, we aim to answer the following questions:

1. What barriers do first-generation women name as reasons for the underrepresentation of women in graduate-level computing research?
2. How does interest in research, comfort to do computing research, and previous research experience vary between first-generation and continuing generation women?
3. How did first-generation undergraduate women respond to the Tech + Research workshop?

IV. Methods and Data

A. Sample

This study uses pre- and post-survey data collected during three separate Tech + Research workshop events during the fall semesters of 2018, 2019, and 2020. Due to the unique impact of COVID-19 on the 2020 school year, the 2020 Tech + Research event was moved to a virtual platform. Therefore, only the pre-survey data across all three years was aggregated in order to create consistency across the data. The post-survey data was analyzed separately by year and only the 2019 and 2020 data were analyzed due to 2018 having too small of a sample size. The aggregate sample included a total of n = 122 participants representing 61 different colleges, universities, and community colleges in the United States.

All Tech + Research participants identify as women or non-binary; the purpose of Technica and Tech + Research is to provide an inclusive space for women and non-binary students within the computing community. However, students who identified as non-binary were not included in our study due to small sample size. Every Tech + Research participant is also a current undergraduate student majoring in a computing-related field - computer science, computer engineering, engineering, information technology, mathematics, statistics, and/or another STEM-related field - or has prior experience with computing. All demographic data was obtained from the participants' Tech + Research applications and demographic questions on the pre-survey asking specifically about race, year in school, and first-generation status. Table 1 provides a complete demographic breakdown of survey respondents each year by class year, race, major, first-generation status (note: this table includes ALL Tech + Research participants, not just those who completed the surveys).

TABLE I. TECH + RESEARCH PARTICIPANT DEMOGRAPHICS BY YEAR

Year	*2018*	*2019*	*2020*	*Total*
Total Participants	59	54	75	188
RACE				
Black/African American	10 (17%)	9 (17%)	8 (11%)	27 (14%)
Asian	31 (53%)	27 (50%)	48 (64%)	106 (56%)
Native Hawaiian/ Pacific Islander	0	1 (2%)	1 (1%)	2 (1%)
Native American/ American Indian	0	0	0	0
Hispanic/Latino	2 (3%)	2 (4%)	4 (5%)	8 (4%)
White	7 (12%)	6 (10%)	9 (12%)	22 (12%)
Other	7 (12%)	7 (13%)	2 (3%)	16 (9%)
Decline to State	2 (3%)	2 (4%)	3 (4%)	7 (4%)
FIRST GENERATION				
Yes	12 (20%)	12 (22%)	19 (25%)	43 (23%)
No	47 (80%)	42 (78%)	56 (75%)	145 (77%)
MAJOR				
Computer Science	39 (66%)	33 (61%)	46 (61%)	118 (63%)
Information Science	7 (12%)	10 (19%)	6 (8%)	23 (12%)
Engineering (Broad)	6 (10%)	2 (3%)	11 (15%)	19 (10%)
Mathematics/Statistics	3 (5%)	0	6 (8%)	9 (5%)
Other	3 (5%)	9 (17%)	4 (5%)	15 (8%)
Blank	1 (2%)	0	2 (3%)	3 (2%)
YEAR IN SCHOOL				
Freshman	12 (20%)	7 (13%)	13 (17%)	32 (17%)
Sophomore	11 (19%)	17 (31%)	16 (22%)	44 (23%)
Junior	17 (29%)	14 (26%)	30 (38%)	61 (33%)
Senior	19 (32%)	16 (30%)	16 (23%)	51 (27%)

B. Measures

This study examines the intersectional experiences of first-generation students compared to continuing generation students by using inductive coding [23] to analyze open-ended questions and quantitative statistical methods to analyze yes/no and Likert-scale (closed-ended) questions. Open-ended questions were included in the analysis in order to gain a stronger understanding of how the women view research, why they believe women are underrepresented in computing, and what intersectional barriers they may have endured while pursuing computing degrees.

Survey questions were organized by research question and separated by question type (open or closed). This process helped with organizing the data and determining which questions will undergo quantitative statistical analyses. Regardless of question type, all survey scores were assigned a numerical value in order to quantitatively assess and summarize participants' responses. A total of 8 survey questions were analyzed in this study. All survey questions assessed in this study are outlined in Table 2.

TABLE II. PRE/POST-SURVEY QUESTIONS ANALYZED

Pre-Survey				
#	**Question**	**Type of Question**	**Scoring**	**RQ**
1	Have you ever encountered any barriers to trying to become more active in the computer science, engineering, or technical community at your school?	Open-Ended	Manual Codes	1
2	Women are underrepresented in undergraduate computing degree programs. In your opinion, what do you think is the single greatest reason for this situation?	Open-Ended	Manual Codes	1
3	Have you participated in research at your school?	Closed-Ended (yes/no)	Yes = 1 No = 0	2
4	How comfortable are you with completing research?	Closed-Ended (Likert Scale)	10 = very comfortable 1 = not comfortable at all	2
5	How interested are you in research?	Closed-Ended (Likert Scale)	10 = very comfortable 1 = not comfortable at all	2
Post-Survey (2019 and 2020 Only)				
6	Did you enjoy your experience with Tech + Research?	Closed-Ended (yes/no)	Yes = 1 No = 0	3
7	Do you think this experience may be beneficial for applying to a graduate program?	Open-Ended	Manual Codes	3
8	What was your experience like in working with an all-female/non-binary team to complete your project? Was it different from other teams you've worked on in computer science?	Open-Ended	Manual Codes	3

We used the coding framework by [22] to manually code for emergent themes across the survey data. Participant responses that overlapped were grouped into categories. This coding process helped us summarize the data and build connections across participants' responses. Table 3 offers examples of how the open-ended survey data was coded.

TABLE III. MANUAL CODING OF OPEN-ENDED QUESTIONS

Transcription	Data Source	Emergent Category
The single greatest reason for this is early exposure in childhood before the self-esteem issues begin to really sink into the human psyche. Most women do not pursue computer science because they do not have role models to reflect from or have any one	Pre-Survey, Q2	Lack of Role Models; Lack of Exposure
I feel imposter syndrome because I don't feel like I'm "STEM" enough to wholeheartedly love or do well in Computer Science	Pre-Survey, Q1	Imposter Syndrome
It gave me the experience that I needed to do better on future research projects, including applying and being prepared for a graduate program	Post-Survey, Q7	Research Knowledge
This experience provides me with a glance into what research is like. It also helps reflect that I have a familiarity with research.	Post-Survey, Q7	Computing Identity Development; Increased Research Knowledge
It was awesome. I wish we had this opportunity more often. Everyone is included and everyone's opinions and/or ideas are treated equally. It was one of the best times I've ever had working in a group.	Post-Survey, Q8	Empowering Community

V. FINDINGS

We use the intersectional computing identity theory [26] to outline three key themes that arose from the data: 1) both first-generation and continuing generation participants report that their gender identities pose the largest barrier to becoming active in the graduate computing community; 2) first-generation participants express equal interest in research compared to continuing generation women but experiences related to their first-generation status impact their comfort levels with doing research; and 3) the Tech + Research workshop was an important space for first-generation women to identify with computing research and develop positive computing identities within a supportive community environment. Each theme reflects the complex effects of the intersectional experiences of first-generation women and how these experiences impact their access to graduate-level computing programs.

A. Barriers to Computing Identity Development (RQ1)

We answered the first research question by assessing participants' responses to questions 1 and 2 on the pre-survey. We were able to identify four main factors that first-generation undergraduate women name as barriers to graduate school: limited exposure to computing learning opportunities, feelings of exclusion and imposter syndrome, sexism and racism within the computing community, and issues of access. The intersection computing identities framework [27] helped to identify the intersectional levels of oppression that impact how first-generation women access the computing community and develop computing identities. Comments from first-generation participants showed that their gender identities posed the greatest barrier to their participation in the computing community. For example, one participant shared, "It's hard to be a woman in STEAM. I've had many negative interactions throughout my school career with men who think I am not smart enough, or talented enough to be in a STEAM field. I have been talked down to and laughed at and that has made it really challenging at times." There were no differences in the frequency of responses regarding gender discrimination between the first-generation participants (50%) and the continuing generation participants (50%). Both groups indicated that they were discriminated against on the basis of their gender. However, descriptive statistics show that when naming why they believe women are underrepresented in computing, more first-generation women (61%) compared to continuing generation women (51%) attributed underrepresentation to discrimination.

Participants from both the first-generation and continuing generation groups explicitly named other forms of intersectional oppression that make it difficult for them to be more active in the computing community. For example, in response to the question, "Have you ever encountered any barriers to trying to become more active in the computer science, engineering, or technical community at your school?" one first-generation participant named racist and sexist behavior in their university by stating, "Yes, instructors being racist and benefiting males over females." Another continuing generation participant also wrote, "Being a minority in my field makes it very difficult." Many participants also attributed the lack of adequate exposure and role models in the field to feelings of ostracization and not being good enough to succeed in the major. In total, 17% of participants stated that imposter syndrome makes it difficult for them to be active in the computing community and take on leadership opportunities. One continuing generation participant shared that they had a "Fear of failure and of not matching up to male counterparts in the same field," while a first-generation participant said that computing is "difficult material such that you need support from people who are doing it." These findings highlight that the experiences of women within the computing field are not monolithic and that the underrepresentation of first-generation women and women of color is a result of various overlapping factors.

B. Experience, Interest, and Comfort Levels (RQ2)

Independent two-sample Wilcoxon rank sum tests were performed in order to compare the median comfort and interest levels of first-generation women and continuing generation women to complete computing research. Shapiro-Wilks normality tests were used to check for normality of the data and results revealed non-normal distributions of the comfort data from question 4 ($S\text{-}W = 0.961$, $p = 0.0029$) and the interest data from question 5 ($S\text{-}W = 0.802$, $p < 0.001$). According to the Levene's test, homogeneity of variance was satisfied for the comfort [$F(1, 106) = 0.033$, $p = 0.856$] and interest [$F(1, 107) = 3.368$, $p = 0.069$] data. Given the non-normality of the data, Wilcoxon rank sum tests were used for both comparisons

(comfort and interest) instead of the two-sample independent t-test (Table 4).

The results from the Wilcoxon rank sum test of the comfort data provide evidence supporting the conclusion that first-generation women participating in the Tech + Research workshop have lower comfort levels towards doing research compared to their continuing generation counterparts. The effect size for this difference is small (r = 0.217). However, it is important to note that the effect size may be skewed by the unequal sample sizes of the first-generation women (n = 26) and the continuing generation women (n = 101). There was no significant difference in the median interest data between first-generation and continuing generation women.

TABLE IV. WILCOXON RANK-SUM TEST RESULTS

	First-Generation		**Continuing Generation**		
	Mean (SD)	*Median*	*Mean (SD)*	*Median*	*p-value*
Comfort	0.694 (0.467)	5	0.874 (0.334)	7	0.0171
Interest	0.694 (0.467)	9	0.884 (0.322)	9	0.8744

Descriptive statistics regarding participant responses to, "Have you participated in research at your school?" show that first-generation Tech + Research participants report having less research experience (M = 0.308, SD = 0.471) than continuing generation participants (M = 0.429, SD = 0.498). A Chi-Squared Test of Independence was performed to determine if there is a significant association between first-generation status and previous research experience (yes/no; question 3). There was a significant difference in previous research experience between first-generation and continuing generation women at an alpha level of 0.05 [X^2 (1, N = 110) = 4.4, p = 0.0359]. In summary, these findings indicate that both groups are interested in computing research but comfort levels to complete graduate-level computing research and previous research experience varies depending on first-generation or continuing-generation status.

C. The Impact of the Tech + Research Community (RQ3)

A small number of first-generation participants completed the post-survey in 2019 (n = 15) and 2020 (n = 11). Of this sample, all first-generation women participants (2019 and 2020) said that they enjoyed their Tech + Research experience (question 6). Similarly, all first-generation women in both the 2019 and 2020 cohorts said that they believe Tech + Research was beneficial for applying to graduate school (question 7). When looking at the complete sample (all participants), 84% of the women in said that they enjoyed the workshop. Additionally, three themes emerged from open coding of the post-survey questions (questions 7 and 8): participants felt they were a part of an empowering community, had a greater understanding of graduate-level computing research, and developed stronger computing identities.

In 2019, 92% of all the participants indicated that they felt the research workshop increased their knowledge of computing research, graduate school, and the research process. One participant noted, "It has introduced me to such a valuable skill and sparked my interest even more" while another said, "First of all, in even making me consider grad school, and I am more familiar with staff here and I know what people look for in grad students." Similarly, 82% of 2020 participants reported that they found the research beneficial in understanding the graduate school application process. One commented on the benefits of the workshop by saying, "It gave me the experience that I needed to do better on future research projects, including applying and being prepared for a graduate program." Others mentioned how the research workshop helped them learn about the research process: "Yes, because I got to briefly explore a research topic and understand the basics of what research is about." The decrease in the number of participants who found the research workshop beneficial in 2020 could be due to the effects of virtual learning and the COVID-19 virtual transition.

In response to the question, "What was your experience like in working with an all-female/non-binary team to complete your project? Was it different from other teams you've worked on in computer science?" first-generation participants shared that they really appreciated the all-women team because it created an encouraging environment. One 2019 first-generation participant said, "Being able to experience so much support at once was something new. Having an all-female team provided me with a much more comfortable and encouraging environment." In the 2020 group, first-generation participants shared "Yes it was great it felt like such an encouraging space and we were all in similar skills level" and "Yes, it was easy to talk to each other. In other teams I've worked on, it's not always that easy." These comments across both the 2019 and 2020 cohorts indicate the impact of community on participants' interest and enjoyment towards research and computing.

VI. DISCUSSION

The overall goal of this study was to identify factors that contribute to the underrepresentation of first-generation women in computing graduate programs and to evaluate the impact of the Tech + Research workshop on participants' interest to pursue graduate school. Using the framework for intersectional computing identity [28], we determined that first-generation status, and the experiences associated with this identity, influence how first-generation women perceive graduate research in computing; although first-generation women express equal levels of interest towards research, first-generation women report significantly lower comfort levels to complete research compared to continuing generation women. Differences in comfort levels to complete research could be linked to feelings of imposter syndrome and the competitive nature of computing courses [5]. In fact, first-generation women and continuing generation women participating in Tech + Research directly named imposter syndrome and discrimination (on the basis of race and/or gender) as root causes of the underrepresentation of women in computing.

The findings from this study support the argument that more research is needed to understand how students come to develop computing identities [28] and how these identities

shape their pathways to graduate school. Our research indicates that students with intersectional identities, such as being a first-generation undergraduate computing major and a woman, are subject to cultural and systemic barriers that prevent access to computing graduate programs. Participants' emphases of various forms of oppression - exclusion leading to imposter syndrome, limited exposure, and racial and gender discrimination - during their computing journeys shows that the culture of the computing community continues to favor masculine and White ideologies and epistemologies. As a result, students who do not identify as White or male can find it difficult to persist in computing majors and identify with the computing community [11][17][18][28].

Our research also showed that the Tech + Research workshop provided critical social support networks that helped target barriers to representation in graduate-level computing programs. Following their participation in Tech + Research, first-generation students shared that the workshop helped them learn more about the research process and potentially see research as a part of their future. All Tech + Research participants (first-generation and continuing generation) noted that the gender-inclusive teams and the emphasis on community were the most influential factors of the workshop that changed their initial perceptions of computing research. Previous research has shown that exposure to computing research, sufficient community support from leaders in the field, and respect and encouragement from others when pursuing computing are influential factors that contribute to the persistence of women in computing [9][10][19]. Additionally, first-generation students have shared that positive interactions with graduate students are instrumental to gaining insight into graduate-level STEM research [20]. Therefore, more opportunities either through undergraduate courses or workshops like Tech + Research could provide pathways for first-generation women to access computing graduate programs and find their identities validated in the field [34][38].

A. Limitations

This study was mainly limited by the low number of first-generation participants who participated in Tech + Research. As a result, there were large differences in the number of responses from first-generation participants compared to continuing generation participants. Differences in sample size could be due to the fact that first-generation students are currently underrepresented in computing [24] and therefore represent a small pool of Tech + Research applicants. Despite these limitations, the comfort levels to complete research significantly varied between first-generation and continuing generation students, suggesting that more research is needed to understand the complex experiences of first-generation women in computing and their pathways to graduate school. Future qualitative interviews could help explain why first-generation women report lower comfort levels to complete computing research despite expressing interest in the field.

Another limitation of the study is that only first-generation status and gender could be assessed. The number of BIPOC women enrolled in Tech + Research is too small of a sample to analyze. The low numbers of BIPOC women in Tech + Research indicates that more effort should go into recruiting these students and increasing their access to the workshop. Future research should consider looking at first-generation women with additional intersecting identities in order to gain a better understanding as to why this group of students is underrepresented in graduate computing programs.

VII. Conclusion

Very few research studies explore how first-generation women navigate intersectional levels of oppression within the computing community and how this oppression might contribute to their underrepresentation in graduate computing programs. This study furthers our understanding of intersectional computing identities by highlighting how first-generation women navigate being first-generation undergraduate women and what factors are most helpful in creating a pipeline for these students to enter graduate school. Most notably, the Tech + Research program provided a communal space for first-generation to learn about research and interact with faculty and graduate students in an encouraging environment that they may not typically experience in the traditional university computing class setting. More research is needed to determine how race and socioeconomic status factor into the underrepresentation of first-generation students. Without the right structural and communal support to succeed, as well as research that acknowledges the relationship between intersectional oppression and underrepresentation, we will continue to see first-generation women underrepresented in graduate computing programs. Educational institutions hold a critical responsibility to create learning environments that encourage the positive construction of students' computing identities.

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