Software Guild: A Workshop to Introduce Women and Non-Binary Undergraduate Students from other Majors to Computing

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Abstract

It has been well established that women and non-binary individuals are minoritized in the field of computing, despite large-scale efforts to remedy this gender imbalance. In this paper, we describe our approach, which involves the creation and implementation of a week-long, extracurricular workshop called a "Guild." With our program, we aspired to introduce women and non-binary undergraduate students from other majors (e.g., biology, nursing, and business) to computing concepts. The Guild was held in the winter of 2022 at a large urban public university in the Southeast. It gave students the chance to engage in experiential software projects, community-building activities, and mentorship from computing majors and industry professionals. In our research, we applied disciplinary identity theory, with a focus on computing identity, to explore participants' perceptions of the experiences and the impact of the Guild on their future computing aspirations. Towards this goal, we used a convergent parallel mixed-methods approach. We conducted pre- and post-workshop surveys of (n = 34) students' impressions and goals. In the analysis, we quantitatively assessed responses around students' computing identities and qualitatively evaluated open-ended questions about the Guild using thematic analysis. The findings demonstrated that the participants perceived the workshop as valuable and enabled them to see how computing can be a medium to solve problems of human interest as well as a tool of self-expression. In particular, participants reported that the empathetic assistance given by the peer mentors made the learning process smoother, thus making it inspiring, engaging, and less intimidating. Going forward, more experiments and fine-tuning are needed to continue to scale and improve the Guild. However, we hope the description of our workshop and findings from our investigation encourage other researchers and educators to consider similar approaches to engage women and non-binary students in computing.

1 Introduction

While decades of efforts have sought to broaden participation in computing, women and non-binary students remain minoritized in the discipline [1, 2]. The lack of gender parity poses an ongoing challenge for post-secondary academic institutions in the United States (U.S.). According to the 2021 Taulbee report [2], 22.3% of baccalaureate degrees in computer science (CS) were awarded to women, and approximately zero percent of degrees were awarded to non-binary students. The extent of the problem is especially apparent when one considers that the representation in the U.S. is quite different, with 50.5% of the total population of the country identifying as women [3] and 1.6% identifying as transgender or non-binary [4]. Gender disparities in computing degrees awarded can further contribute to inequities observed in the

workforce for technology roles, which can lead to a lack of diversity in perspective, thinking, and tools developed [5]. To combat these problematic statistics, in this paper, we share our efforts surrounding a program established to encourage undergraduate women and non-binary students to engage with computing.

We created a week-long workshop, termed a "**Guild**," to provide women and non-binary students with opportunities to delve into activities involving the use of computing. However, we want to acknowledge that gender identity is a social construction and that it can be fluid over time [6]. Specifically, we aimed to promote the Guild to non-majors, allowing them to solve real-world problems of human interest in areas such as art, community engagement, and the life sciences. We enlisted highly qualified teachers and professors, peer mentors, and industry mentors to create a nurturing learning community and provide support throughout the experience.

In our investigation, we explored how the program may have impacted students' disciplinary identity, specifically applying the guiding framework of computing identity. The research questions (RQs) that we sought to answer in this study were:

- **RQ1:** *How did specific computing-related activities in the Guild impact women and non-binary students' computing identities?*
- **RQ2:** *How did students perceive the value of mentorship and teaching assistants as they engaged with computing concepts?*
- **RQ3:** *How did students feel about the community developed within the Guild?*

We took a convergent-parallel mixed methods approach to obtain insight into how the experience impacted the students' computing identities and their perceptions about the program. Surveys were administered at the start and end of the program, using a combination of closed-ended Likert-scale items and open-ended questions. The data were analyzed using quantitative and qualitative methods, which we will elaborate on later.

The paper is organized as follows: we discuss the background related to the research in Section 2 and will present an overview of the week-long Guild workshops in Section 4. Details of the methods that we employed in our study, including the data collection and analyses, are articulated in Section 5. The results of our study and a discussion of our findings are described in Sections 6 and 7. In Section 8, we address the limitations of our study. Finally, we present the key takeaways from the Guild workshop and its implications for other researchers who would like to adopt or continue similar efforts in Section 9.

2 Background

Women have continued to be minoritized in computing fields in the U.S. over multiple decades [1]. Data from the Cooperative Institutional Research Program (CIRP) Freshmen Survey revealed that while the percentage of men planning to major in computing in post-secondary institutions rose from 3.3% to 9.3% over a ten-year period ending in 2000, the corresponding rise for women was only from 1.5% to 1.9%. Over the next decade, the percentages saw a decline for both men and women, with the rates dropping to 3.3% and 0.4% by the year 2011 for men and women, respectively [7]. Even a decade later, in 2021, the percentage of women graduating with a bachelor's degree in computing in the U.S. was a mere 22.3% [2]. In light of such trends, scholars

have considered the multitude of factors that may contribute to the low levels of women's engagement, participation, and retention in computing fields in the U.S. [8, 7, 9].

Many potential concerns are cited as the cause of these inequities in representation, such as stereotype threat [10, 11, 12, 13]. Stereotypes about the ability of students who are successful in computing based on their gender and about the culture as it relates to the people, work, and values in the field of computing have been described as problematic [14]. It has been suggested that such beliefs and expectations can lead to women having to "actively negotiate their identities in the face of the masculine stereotype of the computer geek" [13, p. 413]. As a result, women often believe the misconception that if they have not been programming since the age of 10, they have no chance of being successful in the field of computing, and others have mentioned that this may act as a deterrent for students to even attempt to enter the discipline [14].

Students may be exposed to stereotypes through the media, through people who are thought to represent the field, and through their immediate environments [14]. However, creating academic opportunities for students to engage with successful women in Science, Technology, Engineering, and Mathematics (STEM) fields has been shown to combat negative stereotypes. Stout et al. [12] illustrated that not only were the ill effects of negative stereotyping attenuated through exposure to experts that identified as women in STEM fields, but the participants actually benefited from the interaction through a positive change in their self-concept and self-efficacy in the domain areas.

Fisher et al. [15] suggested women in computing may lack preparedness relative to their male counterparts, since they had limited prior experience in the discipline at their high schools. They concluded that most of the women were motivated by the purpose behind computing rather than the sheer act of interacting with a computer. Comparatively, they observed that international women were motivated to enter the computing field because they perceived it to be a pragmatic and highly employable career field.

Along these lines, it is critical to note that women are not minoritized in computing globally. Countries such as Malaysia, Mauritius, and Taiwan have more equitable (or even higher) representation [13]. Studies have described how nuanced cultural factors may also play a role in such choices and that they can influence perceptions about the field [16, 17]. For example, women in certain countries with a high Muslim population tend to perceive computing as a more feminine field relative to other traditional fields of engineering [16]. As a result, they tend to have a higher representation than in the U.S. Similarly, women in India are more open to computing, viewing it as offering "lucrative jobs, high salaries, professional careers, safe office working environments, and economic independence" [18, p. 20]. Although they still remain marginalized overall, they represent 40% of undergraduate students in computer science and computer engineering [17], a higher percentage than is observed within the U.S.

Scholars have suggested multiple approaches to broaden participation, such as proximal socialization experiences [19]. Positive peer experiences coupled with community-building activities have been shown to enhance students' persistence. Likewise, research experiences for undergraduates (REU) have been demonstrated to cultivate sustained interest in computing and further encourage persistence for women [20, 21].

Another approach adopted to increase the "stickiness" of women in computing was to

contextualize the discipline within various domains where it is being applied in the real world [22]. Educational institutions have been searching for effective ways to introduce computing to non-majors. Cross-disciplinary efforts at an urban liberal arts college have resulted in a collaboration between the computing and humanities departments to offer courses on interdisciplinary themes such as data visualization, bioinformatics, and natural language processing, to name a few [23]. These efforts, over a ten-year period, successfully increased the number of women students enrolled in computing at colleges while simultaneously increasing the overall enrollment of students in a computing course. It has been suggested that Australian universities, "positioned as gatekeepers into the degree programs and gateways into a computer science career – can act as that critical mass by supporting women and educating men about respectful behavior and gender equity" [13, p. 407]. However, this is something that is also true in the U.S. Administrators and faculty at colleges of computing must continue the work of making the environment in their institutions conducive and inviting for students of all abilities and backgrounds to succeed.

In the work that follows, we describe our efforts to engage women and non-binary students in computing through the Guild. We intentionally include interdisciplinary aspects to help students make connections with other fields, and seek to build a supportive community as part of the program. It is our aim that such programs can help combat negative perceptions about the discipline and support a broader audience so that students can envision themselves in the field.

3 Theoretical Framework

Since we were interested in studying the impact of the Guild workshop on students' perceptions of how they fit into the tech ecosystem, we grounded our work in the theoretical framework of computing identity, as depicted in Figure 1. Computing identity is considered a form of disciplinary identity [24]. The four sub-constructs that researchers use to describe computing identity include: 1) Interest; 2) Sense of Belonging; 3) Recognition; and 4) Competence/Performance [25, 26].

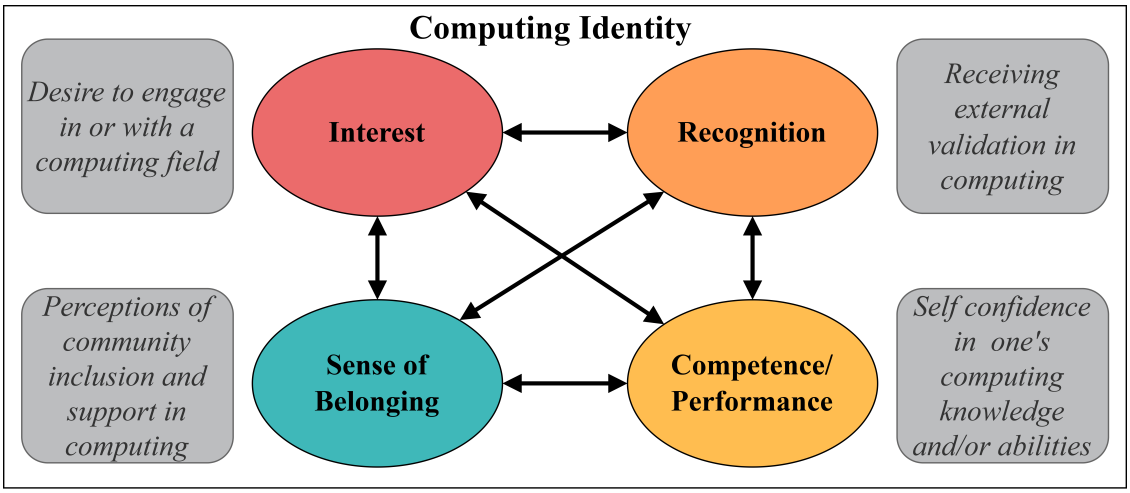

Figure 1: Computing identity framework, adapted from [26]

We define **interest** as the extent to which a student desires to actively engage with a computing

subject area, including their willingness to explore and learn about topics related to the field [25, 26]. **Sense of Belonging** encompasses all aspects of community spirit and support that students perceive to exist for themselves as they navigate their learning experiences in computing. **Recognition** refers to the sense of validation and acceptance that a student receives from various personal stakeholders, such as family, peers, and mentors. Finally, **competence/performance** is the closest construct to a student's feeling of self-efficacy and indicates their level of self-confidence in their knowledge and abilities in computing. While the four sub-constructs measure distinguishable aspects of a student's sense of identity in a field, they also influence each other in a dynamic manner based on a student's unique environment and context [24], a facet we indicate with bi-directional arrows.

Students' computing identity has previously been used as a measure of persistence [27] and also their career choice [24]. We applied the computing identity framework to study students' ties to the discipline and the impact of the Guild experience. Computing identity theory shaped our research questions, our survey development, our data analysis, and the interpretation of the results.

4 Our Approach: The Guild

We designed our week-long Guild with the goal of introducing computing to students with little to no prior experience. The concept of the Guild was initially established and deployed through an organization called Break Through Tech (BTT)[1]. BTT is engaged in efforts on a national stage to build a more equitable and diverse tech ecosystem. Although they may work to achieve this goal through multiple mechanisms, Guilds are one of the foundational programs run by the universities that they support. The Guild aspires to give students a chance to explore technology in a low-risk and highly supportive environment. While the general concept is part of a larger initiative, each site is also given the freedom to establish its own program and plans.

The Guild we describe was held at the end of the fall 2022 semester, although we did pilot the program initially in the summer of 2022. There were several key components to our workshop, which we detail as follows: the design (Section 4.1), culture and climate (Section 4.2), skill development (Section 4.3), and community support (Section 4.4). We hypothesized that the culture and climate of the Guild workshop would be critical to the experience for Guild participants. Accordingly, efforts towards this goal were mindfully woven into the fabric of the Guild workshop.

4.1 Overview of Design

The Guild was designed to highlight that computing can be both a creative tool deployed to create art (visual and musical) and a medium to solve problems of human interest in domains such as life sciences, community engagement, and the environment, among others. While the Guild teaches introductory technical skills to the participants, the workshops are not designed as a boot camp to teach any particular technical skill or programming language. Instead, the purpose of Guild is to show participants that they can deploy even rudimentary technical skills in ways that could solve problems in their immediate communities and that they have the power within themselves to create change through computing and collaboration with each other.

[1] https://www.breakthroughtech.org

Given that communal goals and altruistic purposes have been described as important to addressing a "lack of interest" in STEM for women [28], we assigned our Guild a theme with a social impact message: "Empowering Communities." Then, the students worked in teams to identify problems that they wanted to tackle that fit within the broad theme provided to them. Students were charged with designing a project where they attempted to solve the problem that they had previously identified, using newly acquired technical skills cultivated during the week. The Guild workshop culminated in a formal group presentation where the teams presented the problems identified and received feedback from the whole group.

The schedule for the Guild workshop is based on a curriculum designed by the first and fifth authors and is shown in Table 1. As illustrated, we included a number of exercises, topics, games, presentations, and opportunities for hands-on experience. The schedule was created such that all basic technical skills were taught during the first two days of the workshop, and then on day 3 of the workshop, we included activities to help participants practice these skills.

Our curriculum was devised to touch on interdisciplinary topics over different days, which could appeal to a wide range of interests (i.e., art, music, community involvement). Examples of these activities included creating a self-portrait using programming, composing musical tunes with Python coding, and crowd-sourcing local and useful information on a map through an open-source software program. Also, the time allocated to the design challenge project increased as the week progressed so that participants could dedicate time towards applying the skills learned in order to make progress. The Guild teams met with their peer and industry mentors at the end of every day in order to get input and feedback as they progressed on their design projects. The last day of the workshop was dedicated to project presentations with feedback from the faculty and a panel discussion with professionals from the industry.

4.2 Culture and Climate

Scholars have previously described the importance of creating welcoming spaces to encourage women and non-binary students to learn and explore computing topics [29]. Accordingly, the physical environment of the Guild was intentionally set up to make it safe and inviting for all participants. The walls and the whiteboards displayed welcome messages and holiday wishes, while other areas of the walls were designated as "parking lots" where the students could post comments, ask questions, and share messages with each other. Participants were fed healthy food for breakfast and lunch and were given the opportunity to share their meals in a space together with the entire Guild community. Every day involved ice-breaker activities that were played after meals to allow participants to get to know each other informally. In addition, to further ensure an inclusive culture, all personnel who were involved with the implementation of Guild were trained to be mindful of the impact of their actions, words, and body language as they interacted with the participants.

4.3 Skill Development

We sought to develop professional and technical competencies over the course of the program. While the Guild was envisioned as an opportunity to engage students with computing concepts, participants were also taught critical non-technical, professional competencies that have been shown to be important in helping the students grow into successful collaborators and thinkers. Some examples of these skills include learning about the design process for problem-solving [22],

	Day 1 (Monday)	Day 2 (Tuesday)	Day 3 (Wednesday)	Day 4 (Thursday)	Day 5 (Friday)
8:30 - 9:00	Breakfast	Breakfast	Breakfast	Breakfast	Breakfast
9:00 - 9:15	Pre Survey	Icebreaker 2	Icebreaker 3	Icebreaker 4	Project Presentations (10 minutes per team) 5 teams
9:15 - 9:30	Icebreaker 1	Let's PB & J - Algorithms Demystified!	Self Portrait/ Animation	Mapping Activity	
9:30 - 9:45					
9:45 - 10:00	Welcome and Overview				
10:00 - 10:15	Self-Portrait Exercise on JavaScript	Data Science: An Introduction	App Inventor Let's make a simple App	Computational Thinking Module	
10:15 - 10:30					
10:30 - 10:45					
10:45 - 11:00	Break	Break	Break	Break	Break
11:00 - 11:15	Self-Portrait Exercise	Intro to App Inventor	Ricky's Tunes - Creating music with Python code	Project Work	Project Presentations (10 minutes per team) 5 teams
11:15 - 11:30					
11:30 - 11:45	Hands on Mapping	Presentation Skills			
11:45 - 12:00			Early Lunch		
12:00 - 12:15	Theme, Project Overview, Teams				
12:15 - 12:30					
12:30 - 12:45	Lunch	Lunch	Project Topic Presentations (5 minutes per team)	Lunch	Lunch
12:45 - 1:00					
1:00 - 1:15	Intro to Mapping Open Street Maps	Emotional Intelligence Module Presentation		Artificial intelligence A friendly Introduction	Presentation Feedback
1:15 - 1:30					
1:30 - 1:45					
1:45 - 2:00					
2:00 - 2:15	Design thinking	Ricky's Tunes - Creating music with Python code	Academic Advising confirmed	The "Tunes" Friendly Competition for the BEST Tune	Post Survey
2:15 - 2:30					BTT Completion
2:30 - 2:45					Advice for Future Guild
2:45 - 3:00	Break	Break	Break	Break	Break
3:00 - 3:15	Meet your teams	Project Outlines and Planning	Project Work	Project Work	Career Panel
3:15 - 3:30					
3:30 - 3:45	Time With Mentors: Project Results Review	Time With Mentors: Project Results Review	Time With Mentors: Project Results Review	Time With Mentors: Project Results Review	
3:45 - 4:00					
4:00 - 4:15					Reflections, Feedback, Photos
4:15 - 4:30					
4:30 - 4:45	Reflection	Reflection	Reflection	Reflection	Closing and Thank You!
4:45 - 5:00					

Table 1: Guild Schedule

emotional intelligence [30, 31], and effective communication skills [32].

Introductory technical skills were covered early in the Guild workshop so that the participants could start applying these skills and programming languages right away as they began collaborating with their teammates for their group design challenge. Covered material included: JavaScript, Python, Open Street Mapping software, MIT AppInventor, and data analysis tools such as the Common Online Data Analysis Platform (CODAP).

4.4 Community Engagement

The Guild workshop was structured so that students received messages about the impact of computing from a variety of sources. They interacted with the professors and other educators who ran the workshop sessions, with mentors from their community of peers and from the industry who joined virtually via Zoom, with representatives from the university's advising team, and with members of a diverse panel who discussed the state of women in the technology space and approaches to facing some of the challenges arising from the lack of diversity in the ecosystem. A major support system for the Guild scholars was peer mentors and teaching assistants, who were embedded within the student teams for the duration of the week-long workshop.

The peer mentors were selected from the previous iterations of the Guild workshop. The selection criteria for the peer mentors included favoring students who demonstrated qualities such as empathy, an ability to guide and coach fellow students, and those who were deemed willing to learn. The participants spent an extensive amount of time with their teammates and their assigned peer mentors, thus forming strong ties within the time span of the Guild workshop. However, community building was not only enacted directly within the program.

Communication between all the members of the Guild community was done through the Discord application, allowing participants to collaborate and communicate with each other beyond the working hours of the workshop. The peer mentors, professors, and educators were able to assist and help the participants with queries with short turnaround times. The Discord app also allowed for free and easy sharing of community resources between participants and the workshop organizers. The participants were also given daily survey feedback forms that they filled out anonymously at the end of each day, which was followed up by a forum with the whole group where participants who wished to share their feedback and thoughts were given a chance to do so. This gave the organizers of the Guild a chance to continuously improve the workshop experience through ongoing efforts to address all reasonable requests received from the participants at the end of each day.

5 Methods

To analyze the impact of the Guild workshop on students' computing identities, we used a convergent parallel mixed-methods approach. In this section, we describe the efforts that were used to recruit participants, the demographics of participants, and data collection. Afterward, we separate out the quantitative and qualitative analyses conducted.

5.1 Recruitment Efforts

Multiple avenues were used to advertise the Guild workshop, with the goal being to recruit 40 students who were currently attending the university. Given that we wanted to introduce computing to students from other majors, these efforts focused largely on non-computing majors.

Although we did not exclude any student who wanted to apply, the marketing materials for the program specifically mentioned a workshop for "women (cis and trans), non-binary, and underrepresented individuals." Studies have described how it can be important for girls to see others like them so that they can picture themselves in the field [33, 34]. As such, we deliberately selected a background image for the marketing flyer that depicted two smiling women.

Information about the Guild workshop, using the flyer already described, was disseminated through physical posters on campus as well as posts on social media apps such as Instagram. Targeted emails were also sent to students from various other majors at the university to reach a larger audience. These emails included messaging about how computing could be applicable to those specific disciplines to encourage students to find connections and consider how the program could be useful for them.

5.2 Demographics

In total, 39 students participated in the Guild. This study leveraged this population, using convenience sampling to solicit participants. As a result, we included $n = 34$ in the analysis, who completed both the pre- and post-experience surveys. Their self-reported demographics are illustrated in Table 2, with information included about their race and ethnicity, gender identity, and major. Note that the numbers may not add up to 34 for the "Race and Ethnicity" category since some participants identified as belonging to more than one categorization.

A majority of the Guild participants (85%) identified as either Black/African American or of Hispanic, Latinx, or Spanish origin, and predominantly self-identified as either women or non-binary (94%). While 29% of the participants were declared to be in a computing major, they were so early in their plan of study at the university that they could be considered novices in the field of computing.

5.3 Data Collection

We conducted a survey in Qualtrics at the start and end of the week-long Guild experience, consisting of both closed- and open-ended questions. The full list of questions we evaluated in this work is provided in the appendix. To explore the impact of the Guild on students' computing identity and its sub-constructs (i.e., interest, performance and competence, recognition, and sense of belonging), we used established questions already validated in prior studies [35, 26, 25]. The multiple choice questions used a 5-point Likert scale that ranged from "Not at all" (0) to "Very much so" (4).

5.4 Quantitative Analysis

Quantitative data was cleaned and analyzed using RStudio in the R programming language (version 4.2.1). In the analysis, we explored computing identity as described in previous studies [35, 26, 25]. An exploratory analysis examined descriptive statistics (e.g., means, standard deviations) around the different aspects of computing identity [36]. Then, for each of the sub-constructs, we ran the Shapiro–Wilk test to check for a normal distribution [37]. Since the distribution was not normal, with a significance less than 0.05, we used the non-parametric version of a paired t-test, also known as the Wilcoxon Signed-Rank Test. This test was used to compare the statistical significance of the difference in survey scores between the start and the end of the Guild experience (a between-subjects analysis).

Table 2: Students' self-reported demographics

Demographic Categorization	**Self-Reported Demographic Label**	**Number of Participants (Total *n* = 34)**
Race and Ethnicity	Asian	5
	Black/African American	13
	Hispanic, Latinx, or Spanish origin	16
	Middle Eastern or North African	2
	White	1
Gender Identity	Woman	29
	Man	2
	Non-binary	3
Students' Major	Biology-related	5
	Business	2
	Computing	10
	Interdisciplinary	1
	Liberal arts	4
	Media	3
	Other Engineering Field	6
	Other Science	3

The competence/performance sub-construct of students' computing identity was evaluated using the following four survey questions: "To what extent do you see yourself as having good computing skills?"; "I am confident I can understand computing-related concepts"; "I can do well on computing and technology tasks"; "I understand computing concepts."

The sense of belonging sub-construct of students' computing identity was evaluated using the following six survey questions: "With respect to the computing and tech community, to what extent do you feel like you are part of the community?"; "With respect to the computing and tech community, to what extent do you feel valued and respected in the community?"; "With respect to the computing and tech community, to what extent do you feel alone or isolated in the community?"; "With respect to the computing and tech community, to what extent do you feel you can share your thoughts/ideas in the community?"; "With respect to the computing and tech community, to what extent do you feel you can be heard in the community?"; "With respect to the computing and tech community, to what extent do you feel inadequate as a member in the community?"

The interest sub-construct of students' computing identities was evaluated using the following four survey questions: "Topics in computing and technology excite my curiosity"; "Computer programming is interesting to me"; "I enjoy learning about computing & technology"; "I would like to know what is going on in computing & technology."

The recognition sub-construct of students' computing identities was evaluated using the following four survey questions: "To what extent does your family see you as having good computing skills"; "To what extent do other students see you as having good computing skills"; "To what

extent do your instructors/teachers see you as having good computing skills"; "Others ask me for help with computers and technology."

Given the use of a non-parametric test and the violation of Cohen's assumptions, we calculated the effect size (*r*) using the following formula [38]:

$$r = \frac{Z}{\sqrt{N}}$$

Here, Z refers to the z-value and N refers to the total study sample size. Although different interpretations of the values of *r* may exist, we use the ranges according to [39, 40] as follows: [0.10, 0.30) is a small effect; [0.30, 0.50) is a medium effect; [0.50, 1.00] is a large effect.

5.5 Qualitative Analysis

The qualitative validation and analysis were completed by the first two authors using NVivo for Windows (release 1.7.1). A total of 16 open-ended survey questions were present in the qualitative survey, and they addressed the impact of the following areas during the week-long academic experience: collaboration, community building, peer mentors, future academic and career plans, levels of engagement and interest, and actions of Guild teachers, mentors, or participants. Broadly, the social phenomenon under investigation was to better understand how the participants perceived the Guild in terms of these areas. The responses given were studied by both raters, who independently reviewed them and inductively established tentative codes and themes. They continued to iterate through the content to refine it.

Once no new codes or themes emerged, they came together to discuss and negotiate the final codebook. The two raters then independently coded the responses using the negotiated codes. They obtained a kappa coefficient of 0.8805, which, according to Fleiss et al., is considered an "excellent agreement" [41, p. 609].

5.6 Reflexive Process

Given the influence that our roles and experiences can play in the formation of research questions, the theoretical framework selected, and the interpretation of the data, we want to be reflexive on the possible impact of the researchers involved [42]. The first author identifies as an Indian American woman and was a high school computer science educator for over a decade. She has degrees and experiences in the fields of engineering, business, computing, and educational leadership and is a doctoral student engaged in computer science education research. She served as the leader of the Guild, overseeing the planning and execution. She also led the writing and research efforts, disseminating the pre- and post-survey, analyzing the data, and writing the manuscript.

Meanwhile, the last author is the PI overseeing the study. She identifies as a White, non-Hispanic woman. Her doctorate is in computer science, and her research spans the fields of CS, computing education, and engineering education. She also has degrees and research experience in neuroscience and has spent time in industry. Given her own interdisciplinary background, she participated in some of the Guild sessions and sought to help students from different fields make connections about themselves and their potential future in the field. She was also responsible for guiding the quantitative and qualitative analyses.

The other authors, faculty members in the department, and an Associate Dean played varying roles in the planning and execution of the Guild. They were not involved in the data collection or analysis described. However, they were invited as authors to transparently provide critical questioning about these efforts.

6 Results

Before presenting the outcomes, we want to broadly describe how we applied the data to answer each of the RQs. We used both quantitative and qualitative data to shape our understanding of RQ1, and RQ2 was answered qualitatively. Finally, RQ3 employed both quantitative and qualitative data. In the section that follows, we describe the key findings of each approach separately.

6.1 Quantitative Analysis

Wilcoxon signed-rank tests were applied to compare the students' responses at the start and end of the Guild. We mapped their scores from the questions onto the theorized sub-constructs of interest, recognition, performance and competence, and sense of belonging separately and also considered the combined measure of computing identity. The results of these analyses are presented in Table 3.

Table 3: Quantitative analysis outcomes related to computing identity

	Pre		**Post**		**Wilcoxon**		**Effect Size**
	Mean	*SD*	*Mean*	*SD*	*V*	*p-value*	*r*
Interest	3.08	0.84	3.52	0.72	23.5	***	-0.57
Recognition	1.94	1.15	2.66	1.05	19	***	-0.70
Performance and Competence	2.42	1.08	3.19	0.80	11	***	-0.75
Sense of Belonging	1.81	1.13	3.55	0.63	0	***	-0.85
Computing Identity	2.31	0.86	3.23	0.62	0	***	-0.86

***p<.001

As indicated in Table 3, we examined the linearized pre- and post-experience values in terms of their mean and standard deviation (SD). The *p*-values (<.001) for each item emphasize that there was a significant difference in the students' scores between the two time points. The effect size (*r*) illustrates that all of the sub-constructs and computing identity increased over the course of the experience, with a large effect (since ≥ 0.5 [39, 40]). The negative sign of the values for *r* denotes that the post-test values are larger than the scores on the pre-test [43].

We utilized the findings related to the sub-constructs and overall measure of computing identity to answer RQ1. We also used the results related to "Sense of Belonging" and "Performance and Competence" to answer RQ3. The inclusion of this information allowed us to better contextualize the students' feelings about the community developed.

6.2 Qualitative Analysis

As mentioned, the qualitative findings were applied to shape our interpretation of all three RQs. We observed a total of eight codes and three overarching themes in the data (see Table 4). These codes included: teammates, peer mentors, programmatic structure, acceptance, revelations,

critical thinking, computing shift, and computing application. The eight codes were placed into three broad categories or themes: support, self-discovery, and computing aspirations. In the section that follows, we describe each in greater detail.

Table 4: Themes and codes from qualitative analysis

Theme	Code	Description
Support	Teammates	References to fellow participants in their group and relying on each other for guidance and assistance to achieve goals; Also referred to distributing the work and holding each other accountable; Further spoke to the connections made with their peers
	Peer Mentors	Spoke to the value of the "peer mentors" who were not current participants, but those serving to offer guidance, feedback, or assistance throughout the duration of the program.
	Programmatic Structure	The program's setup, content, environment, as well as the people who contributed to the overall experience beyond their teammates and peer mentors (e.g., teachers, speakers, industry professionals, activities)
Self-Discovery	Acceptance	Spoke to students' willingness to open up to others, share a part of themself, or feeling comfortable with who they are
	Revelations	The "A-ha" moment of making a discovery through an experience or realizing something about oneself; Feeling capable and/or confident
	Critical Thinking	Engaging with problem solving and/or decomposition; Finding solutions to challenges throughout the course of the program
Computing Aspirations	Computing Shift	Mentions of students' intentions to directly change their major, obtain a minor, or take a class in a field related to computing
	Computing Application	Plans to indirectly use computing in the future or incorporate concepts into intended career path without an explicit change of major, minor, and/or course enrollment

6.2.1 Support

The theme of "support" encompassed the academic and non-academic nurturing that the Guild participants reported feeling from the members of their teams, other participants, and their peer mentors. It also spoke to the benefits of structural scaffolding experienced through programmatic variables such as the program setup, environment, and people associated with the program delivery. Students articulated the community they built with their fellow participants, as one mentioned, "*I would describe it as community building because of how much we empower each other with our assignments, projects and accomplishments.*" Another student commented that, "*I felt like I belonged and had a voice*."

In addition to their teammates, the peer mentors offered support in a myriad of ways. Participants emphasized how they found them practically useful and helpful within the program, as one elaborated, "*Peer mentors were not only able, but also happy, to help! They helped to make this*

feel like a safe environment to ask questions." Several students mentioned finding them inspiring, as summarized by another participant:

> *The peer mentors provided a realistic view into the life of a student in CS. Each mentor was raw and honest in their experience being difficult, but it was their passion of overcoming these obstacles and pushing through to evolve as coders in their own right that was admiring. It has inspired me to adopt the same mindset toward coding that yes it's difficult - but not impossible.*

Furthermore, the participants spoke about how the peer mentors helped them envision themselves in the field; as another commented, "*The peer mentors were so wonderful in every way. They helped me figure out how computer science could fit into my future despite me not being a computer science major.*"

Students also spoke about the benefits of the program structure, content, and environment as further enhancing the experience. Many students mentioned it being placed where they were able to share freely, as one participant noted, "*we had discussions, it was a safe space, enlightening, we gave feedback and felt heard.*" Another mentioned that, "*I did not expect to be so in such a welcoming environment. I think the mentor really established psychological safety with the awesome ice breaker.*"

6.2.2 Self-Discovery

The theme of self-discovery included how the Guild impacted the participants' personal growth. Students expressed that the Guild experience allowed themselves to feel comfortable about their own identities, as one person mentioned:

> *I'm normally horrid at socializing, but in one week, I've met a total of approximately seven people, which is more than I usually meet in a month. Not only have I met people, I've been comfortable with my identity around them, and it was very nice to be respected as non-binary. Overall wonderful community building, and I genuinely can't wait for our spring reunion.*

Students also described how the Guild empowered them, making them feel like they could succeed in the field. As one participant suggested,

> *I would describe the experience as a mind-opening experience. Coding is not reserved for those who have a 'natural adept' or 'talent' in where they were attracted to it since one was a child. It's a community that is open and can connect everyone of every field and background. This is what this guild has taught me (along with some basic skills and helpful resources!) that anyone who has these prejudices should realize if they feel like they feel 'inadequate' to join.*

In addition, many participants spoke about how the opportunity made them reconsider their perceptions of computing. It was highlighted that:

> *This was an eye-opening and interesting experience. This was a life changing experience where I learned so many new concepts and this has completely changed my life as there is so much more to computer science.*

Several students also spoke specifically about the activity that exposed them to new ways of thinking and approaches to computational problem solving. This activity was centered around algorithmic problem solving activity, and included props in the form of M&M candies to visualize the steps involved. As stated, "*I felt the most engaged when I was participating in the M&M's coding challenge. My brain was active and I was thinking critically. I felt challenged which I liked.*" Another student confirmed its value, mentioning:

> *The lesson by [faculty member] on Computational Thinking was my favorite part. I enjoyed exploring different options to figure out the best solution, and learning to think in a different way. It felt like a collaborative experience where we were all discovering different pieces of the puzzle.*

6.2.3 Computing Aspirations

The theme of computing aspirations manifested as varying intentions to incorporate or engage with computing in the future. Participants expressed the ways in which they thought computing would play a role in their academic lives and future careers as a direct result of the exposure they had during Guild. Several students talked about a potential change in majors, as exemplified in a comment that:

> *I felt like I've grown so much more than ever in just a short period of time! It had a TREMENDOUS impact on me! Words can't express the gratitude that I have. I definitely will be majoring in Computer Science!*

While not all students wanted to entirely change their course of study based on the Guild, others did suggest finding new avenues to explore the field. A participant stated, "*This experience has not made me want to change majors but I will consider taking a class.*" An additional student said, "*I hope to learn more of coding and continue with the project started in this Guild.*"

Similarly, several students proclaimed a desire to integrate computing into their long-term plans, potentially combining it with another field. Such thinking is exemplified in the comment that, "*This experience made me realize that I could possibly use computer science with my accounting degree in a couple ways. I could potentially be a data analyst.*" Another asserted, "*I now plan to explore possibly game development or try to incorporate it with journalism.*"

7 Discussion

This study assessed the multitude of ways in which the Guild workshop impacted women and non-binary students' computing identities and how participants perceived the Guild. In this section, we describe the impact of the program as it pertains to each of our RQs.

7.1 RQ1: How did specific computing-related activities in the Guild impact women and non-binary students' computing identities?

Quantitatively, all four of the sub-constructs of computing identity, and the combined construct, showed a statistically significant change ($p<.001$) as determined by a paired samples Wilcoxon test before and after the Guild. The measure of effect size (r) illustrated that this was a large effect for all measured. While RQ1 was primarily answered by our quantitative analysis, we better understood the relationships observed through the qualitative analysis.

As described by the theme of *self-discovery*, many of the participants reported that prior to attending a Guild workshop, they had no familiarity with what computing was or what skill sets went into it. They also had stereotypical preconceptions about what a person who is adept in computing looks like, and the notion that computing is all about programming. For these students, the Guild workshop demystified the subject of computing, illustrated that it can encompass many topics, and made the technical concepts more approachable and concrete. Such findings correspond with the work of others who have described that creating experiences that do not perpetuate a culture centered around cisgender heterosexual men, "dude or bro culture," or that disrupt this culture can help students with minoritized identities (i.e., women, people of color, people with disabilities) navigate formal and informal spaces in STEM fields [44].

Responses contributing to the theme of *self-discovery* also included notions that students could see themselves feeling more excited about cultivating computing skills and learning about computing topics. The participants additionally mentioned that they felt acknowledged for their performance in Guild. These reports align well with aspects of computing identity, specifically "interest," "recognition," and "competence/performance."

Many participants also described being excited by the prospect of being able to incorporate computing concepts into their academic and career plans, as defined within the theme of *computing aspirations*. We want to note that the goal of the Guild workshop was not to "poach" students from other disciplines in the university to increase enrollment in the computing department. On the other hand, the intent of the workshop was to educate and encourage students to embrace computing as a problem-solving tool for various domains of study and subjects. While a handful of students expressed a desire to switch their major to computing or to add a CS minor to their academic plans, many envisioned computing fitting into their future in other ways.

As further emphasized by the theme of *computing aspirations*, many of the students expressed an interest in taking a CS course in the near future. They suggested that they were open to incorporating computing into their own domain areas because they understood it to be a tool for problem-solving across subjects. Likewise, others offering a non-traditional, introductory computer science course for non-majors have demonstrated that applying various domains of knowledge, such as digital media, increased students' engagement and encouraged them to take more computing courses [22].

The program structure of Guild was designed with a socially conscious theme that studies have shown to be appealing to women, and the activities were deliberately chosen to emphasize the role of computing in communal and/or societal goals, areas of focus that women are known to gravitate towards [45, 46]. Scholars have described the importance of helping students feel like the work they are doing "has the potential to make an impact in their own lives or their community" [47, p. 35]. Although we did not ask students specific questions about each of the lessons and modules included throughout the Guild curriculum, the participants' responses touched on their value. The sense of purpose behind the learning made the Guild experience very different from a typical boot camp style workshop or a formal course that students would enroll in at their colleges. Working in collaboration with a team of peers while being supported by a team of mentors, as the participants tackled a self-identified socially conscious problem that was meaningful to the whole team, was reported to be a transformational experience. This aligns with the theme of *support*.

7.2 RQ2: How did students perceive the value of mentorship and teaching assistants as they engaged with computing concepts?

The theme of *support* also spoke to the value of peer mentors (teaching assistants) and an environment conducive to learning about computing topics. Peer mentors were cited as critical to helping the participants comprehend the content, allowing them to bridge any potential technical gaps. Our results align with work demonstrating that using learning assistants (peer educators in classroom settings) can strengthen students' disciplinary identities and positively impact affective outcomes [48]. They can also help students feel more prepared and promote the internalization of disciplinary concepts.

Students additionally reported that peer mentors made the environment feel open and welcoming and that, since the student mentors were closer in age to them, their interactions and experiences were highly relevant and relatable. This aligns with the findings from other computing workshops, where employing peer mentors who were approachable and inclusive in their attitudes led to greater self-efficacy and resilience among the participants [49]. Considering that the Guild workshop was the first computing experience for many of the participants, it was important they viewed it favorably. Students who have a positive first experience in computing may be more likely to sign up for another computing course [50].

Role model identification has also been shown to play an important part in outcomes for women in STEM fields and can help to combat such stereotypes about who "belongs" in the discipline [51]. The speech, attitudes, and body language of the peer mentors were reported to be very uplifting and encouraging, which had a positive effect on the psyche and motivations of the Guild participants. Similarly, participants mentioned feeling validated by the experiences of the peer mentors who shared stories of their own personal struggles in the male-dominated tech classrooms, and they described the value of hearing some of their personal coping strategies to persist in this field. Prior studies in engineering have demonstrated that a sense of belonging can be important in helping students view the adversity they face in a male-dominated culture and can even help form friendships with different-gender peers in the field [52].

While the peer mentors were critical to the outcomes, the non-student side of the Guild — professors, speakers, and industry advisors — were also cited as valuable. Scholars have described how supportive computing networks ranging from family to teachers can help set students up for success and encourage them to persist in the field [53]. In the Guild, participants mentioned that the support they received from industry mentors gave them increased confidence that their project ideas and solutions had true merit in the real world. Such perceptions follow the sub-constructs of "recognition" and "competence/performance." Interactions with role models who work in a relevant industry can allow students to envision the possibilities of their own success in the field and their perception of the field's importance [54]. Accordingly, educators and administrators should consider inviting speakers and/or hosting workshops that could give students more opportunities to interact with other women and non-binary leaders in computing fields.

7.3 RQ3: How did students feel about the community developed within the Guild?

Given that undergraduate women in computing may have a lower sense of belonging than men [45], it can be critical to identify opportunities to help women (and non-binary students) feel

accepted and included in the discipline. Over the course of the Guild, we noted a rise in the sub-construct of "sense of belonging" ($p<.001$). The qualitative theme of *support* further highlighted the benefits of the Guild's programmatic structure towards this outcome. Students elaborated more in their responses about how the environment made them feel like they were part of a community.

Students reported that their teams were a major contributor to the outcomes of the experience. They talked about holding each other accountable while also providing assistance. These results further confirm studies that have described that intra-group emotional support can be vital to collaborative learning [55].

Multiple participants mentioned that the experience was positive because the workshop created an atmosphere of mutual respect, inclusion, and psychological safety. Students expressed that the rapport created was enhanced by pushes to share with each other. One student even touched on the community feeling like a family. Such belonging has been described as contributing to women's intention to pursue or aid those presently pursuing, computing [53]. For others looking to create such settings, encouragement to speak up and be kind to others can be a first step. Another easy-to-implement approach is to promote others' use and application of inclusive language.

The Discord platform was chosen by the organizers as a communication tool for the Guild. It has been described that computing students can use Discord for socialization and community building [56]. Within the Guild, participants were encouraged to speak with each other freely even before the start of the program, and they continued to use the platform to chat even after the experience ended. Conversations through Discord included motivating each other and applauding each other's successes on their projects and even incremental stages of them, such as logo design. They reported feeling that they belonged to a community that helped one another advance instead of being competitive with one another. Accordingly, we suggest expanding the use of Discord to other formal and informal programs to help with community building and provide students the opportunity to connect through additional outlets.

Peer mentors (the teaching assistants) also actively joined the conversations on Discord, providing additional opportunities to get feedback and ask questions. This is something that can be critical since the participants mentioned in their responses that being able to ask questions without any sense of discomfort or fear during the Guild workshop was especially beneficial. Given that other studies have mentioned gender disparities in which women may lack confidence in asking questions in CS classes relative to their male peers [57], this suggests an additional way to provide a less intimidating forum. The Guild offered support in multiple ways for students: they could take their technical and non-technical questions or queries to their teammates, their Guild cohort members, the peer mentors, the program facilitators, and/or professors from the university. Other researchers and practitioners interested in recreating or expanding on our Guild efforts could take this aspect of the program into account and provide students more chances to ask questions through varied individuals — so that they can find someone they feel comfortable with.

Participants also described how much they appreciated opportunities to collaborate, give constructive feedback, and share accomplishments, as evidenced by the quantitative rise in the computing identity sub-construct of "performance and competence" ($p<.001$). In addition, the

participants gave feedback that illuminated the value of having a common goal. They mentioned that having a united mission, in the form of the team's design project, was instrumental in bringing them together and fostering camaraderie. They also noted that solving the design problem required everyone's cooperation, which further enhanced the bonding. Other researchers have described that successful teamwork entails the cohesion of team members and well-defined objectives [58]. Providing similar opportunities to address a problem together may be something that could be included in more courses to establish a community for students.

8 Limitations

There are several limitations we want to acknowledge. First, the study has a small n value since this was an exploratory study, limiting its statistical power. In the future, we plan to scale up the Guild, hosting the workshop multiple times throughout the academic year, and allowing for a greater capacity of participants. In addition, going forward, we would like to conduct qualitative interviews to allow for further expansion on some of the items mentioned in the open-ended responses and to delve into some of the relationships observed. Also, while we did ask students about their future plans related to computing, there is no guarantee that they will follow through on their expressed interest in continuing with computing or in pursuing a computing course, minor, and/or major. This is something that requires longitudinal tracking of the students' progress, which we do plan to implement going forward but cannot speak to within the confines of this study.

In addition, several other items may have played a role in the outcomes. We acknowledge that it is impossible to gauge the authenticity of student responses to the survey given that they were compensated monetarily. There is a possibility that some students may have unconsciously responded to the surveys in a positive manner because they believed that they would be helping out the workshop organizers, who were paying them for the workshop. Finally, the findings presented are the result of a single Guild offered in a single location, which may not be reflective of the experiences of all students across institutions.

9 Conclusion

In this paper, we describe our efforts to design and host a week-long workshop to engage more women and non-binary students with computing. We evaluated the program, its activities, mentorship, and perceptions of the community through our RQs. The findings of our quantitative analysis (using Wilcoxon signed-rank tests) demonstrate that the Guild experience greatly increased the overall computing identity of the participants. The four sub-constructs of computing identity —competence/performance, interest, sense of belonging, and recognition— also increased over the course of the program. The qualitative analysis illustrated that the participants thrived under the guidance of peer and professional mentors and that they enjoyed working on technical design projects with their teams. In addition, the analysis delineated that students found the experience to be rich with community-building opportunities. They described feeling welcomed and accepted. We hope the descriptions of our workshop and the promising results of this investigation encourage other researchers and educators to further expand on the success of this Guild. It is critical to create opportunities to enhance exposure to computing and to demonstrate how it can be applied to a range of fields and topics. Although change is a process and may take time, this is a step forward in the larger goal of broadening participation in computing and creating equitable and welcoming spaces for all in academia and industry.

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Appendix

We present the questions included in the post-experience survey that we employed for our analysis in Table 5.

Table 5: Questions included in the survey we utilized for our quantitative and qualitative analyses

Closed-Ended Items Used in the Quantitative Analysis
5-Point Likert Scale Ranging From: "Not at all" (0) to "Very much so" (4)
To what extent do you see yourself as having good computing skills
To what extent does your family see you as having good computing skills
To what extent do other students see you as having good computing skills
To what extent do your instructors/teachers see you as having good computing skills
I am confident I can understand computing-related concepts
Others ask me for help with computers and technology
I can do well on computing and technology tasks
I understand computing concepts
Topics in computing and technology excite my curiosity
Computer programming is interesting to me
I enjoy learning about computing & technology
I would like to know what is going on in computing & technology
With respect to the computing and tech community, to what extent do you ... feel like you are a part of the community ... feel valued and respected in the community ... feel alone or isolated in the community ... feel you can share your thoughts/ideas in the community ... feel you can be heard in the community ... feel inadequate as a member in the community
Open-Ended Items Used in the Qualitative Analysis
How will you describe the experience that you just had to a peer?
Would you describe the experience that you just had as collaborative?
Would you describe the experience that you just had as community building?
Please describe the effect of the peer mentors from the workshop on: a. your comfort level with coding/programming b. your comfort level with designing an application c. your comfort level with cleaning and organizing data d. the learning environment of the experience e. other areas not previously mentioned
Describe the impact of this experience on your future a. academic plans b. career plans c. other plans
At what moment during this experience did you feel most engaged with what was happening?
At what moment during this experience were you most distanced from what was happening?
What action that anyone (i.e., a teacher, mentor, and/or another student) took during this experience did you find most affirming or helpful?
What action that anyone (i.e., a teacher, mentor, and/or another student) took during the workshop did you find most puzzling or confusing?
What about this experience surprised you the most? (This could be about your own reactions to what went on, something that someone did, or anything else that occurred)