



Tracing Participation Beyond Computing Careers: How Women Reflect on Their Experiences in Computing Programs

MELISSA PEREZ and PATRICIA GARCIA, University of Michigan

Norms and values in computing education are constantly changing as dominant narratives about the role of computing in society evolve over time. Within the current evolving landscape of computing education, researchers and practitioners have advocated for ensuring people from all backgrounds, and particularly women, non-binary, and Black, Indigenous, and Latinx people, are able to participate equitably within the field of computing. Yet, the values of computing educational experiences are narrowly framed within career outcomes, such as securing a career in computing, leaving many important experiences and ways of participating in the field out of the picture. To address this, we conducted reflective interviews with women who participated in broadening participation in computing (BPC) programs to understand their perceptions of computing and how it aligns (or not) with what they value about their experiences in computing learning environments. We investigate the following research questions: (1) How do women who participated in BPC programs describe their perceptions of computing? (2) How do those perceptions align or misalign with the program outcomes they valued? The findings from our study call attention to tensions arising from centering “computing careers” in BPC work and highlight the outcomes of participation valued by the women in our study, such as developing communities and relationships, gaining communication skills, and expanding perspectives on skills computer scientists should possess.

CCS Concepts: • **Social and professional topics** → **Computing education**;

Additional Key Words and Phrases: Broadening participation, photo elicitation, qualitative research, women in computing

ACM Reference format:

Melissa Perez and Patricia Garcia. 2023. Tracing Participation Beyond Computing Careers: How Women Reflect on Their Experiences in Computing Programs. *ACM Trans. Comput. Educ.* 23, 2, Article 23 (April 2023), 23 pages.

<https://doi.org/10.1145/3582564>

1 INTRODUCTION

Disparities in the participation of women and racialized minorities in computing continue to persist despite increased efforts to broaden participation in computing. The disparity is significantly greater for women who also identify as racialized minorities due to the cumulative effects of sexism and racism on their educational experiences and overall life chances. While there are numerous compounding factors that negatively impact computing participation rates, prior research

Authors’ address: M. Perez and P. Garcia, University of Michigan, School of Information, 105 South State Street, 4437 North Quad, Ann Arbor, MI 48109-1285; emails: {perezme, garciapg}@umich.edu.

Permission to make digital or hard copies of all or part of this work for personal or classroom use is granted without fee provided that copies are not made or distributed for profit or commercial advantage and that copies bear this notice and the full citation on the first page. Copyrights for components of this work owned by others than the author(s) must be honored. Abstracting with credit is permitted. To copy otherwise, or republish, to post on servers or to redistribute to lists, requires prior specific permission and/or a fee. Request permissions from permissions@acm.org.

© 2023 Copyright held by the owner/author(s). Publication rights licensed to ACM.

1946-6226/2023/04-ART23 \$15.00

<https://doi.org/10.1145/3582564>

has identified a narrow focus on white cisheteropatriarchal capitalist notions of computing as a limiting factor contributing to the persistent exclusion of women and racialized minorities in computing [1]. Based on white cisheteropatriarchal ideals, these models of computing offer learners a limited notion of participation in computing that values economic benefit and focuses on increasing the number of women and racialized minorities in the “tech pipeline.” In this article, we challenge these limited notions of participation through a reflective study of the experiences of women who participated in **Broadening Participation in Computing (BPC)** programs. Often funded by federal and philanthropic agencies, BPC programs aim to significantly increase the participation of women, racialized minorities, and other underrepresented groups in computing. Rather than analyze their experiences through the limited lens of whether or not they pursued a degree or career in computing, this study uses a reflective interview process to surface the BPC program experiences that the women, most of whom also identified as racialized minorities, found meaningful several years after their participation and investigate how those experiences impacted their perceptions of computing and life trajectories.

Our reflective interview process incorporated a photo elicitation activity to answer the following **research questions**: (1) How do women who participated in BPC programs describe their perceptions of computing? (2) How do those perceptions align or misalign with the program outcomes they valued? We draw from the theoretical framework of *figured worlds* [4] to examine computing as a social practice people engage in over time, with regard to particular dimensions of the practice. Given our research aim, our data analysis focused on understanding how the practices, actors, objects, and outcomes that surfaced in the women’s interview responses influenced their perceptions of computing and valued participation outcomes. We draw on an expansive view of “computing” that includes a broad range of disciplines and activities, including knowledge of computer science principles, fluency in specific practices such as programming, experience with the design and development of software and hardware systems, and literacy in using digital tools for multimedia production.

In the following sections, we further expand on the nature of our reflective interviews by unpacking the figured worlds theoretical framework, situating our approach within prior work, and describing the research design. After framing our study, we present a close analysis of three of the women who were interviewed and conclude with a discussion of what their responses tell us about how we can change our understanding of computing education environments toward a broader view of desired outcomes and participation endpoints [5]. Our work contributes a more expansive vision of the value of BPC programs in ways that extend beyond limited career and educational trajectories. By focusing on the participation outcomes and experiences prior participants valued, we offer an alternative way to evaluate the outcomes of BPC programs that does not rely solely on educational and career statistics. While those statistics are important, we argue that a longer term evaluation of what “stuck” with participants years after their participation offers an opportunity to reimagine the values and rationales of BPC programs to create more diverse forms of participation and to develop more equitable approaches for computing education that privilege the rationales, motivations, and desires of learners [3].

2 BACKGROUND

Students’ perceptions of computing are often cited as being a determining factor in the choice to major in computer science or to pursue a computing career [16, 17]. Yet, “perception of computing” carries many different meanings and interpretations; for instance, a perception of computing can be related to who participates in computing, what people who participate in computing do, or why people learn to program [6, 18–22]. Much of the research in this area has used “perception of computing” to refer to one or more of these, mainly drawing on data from interviews [18, 21, 22] and/or

surveys [19, 23]. Other work has used the activity of asking participants to “draw a computer scientist” as a method to assess students’ perceptions of computing, particularly for younger students who may have trouble communicating their perceptions verbally [20, 23]. These studies demonstrate how students from underrepresented backgrounds perceive computing as associated with antisocial behavior, dominated by cis-gender White and Asian men, and primarily coding [17, 16].

These perceptions of computing often reify stereotypes, negatively impacting students’ interest and participation in computing and making them less likely to participate [16]. Their perceptions of the computing field and its values are also tied to their “sense of belonging.” For example, Lewis et al. [24] found that students from underrepresented groups in computing value community, yet feel the work they do as computer science majors does not align with their values.

Influenced by this body of research, many interventions focus on positively changing students’ perceptions of computing to promote a sense of belonging and attract more students to the field. These efforts include highlighting the creative aspects of computing [25] and introducing students to diverse role models [26, 27], among others. However, these still work based on the premise that computing, as an economic endeavor, is the center of participation. While the outcomes from these efforts can have positive effects on learners’ “persistence” in computing, the idea that participation in computing is based on whether or not you are in a “computing career” or major is still evident. Persistence in this case is still defined as whether or not they continue into a narrow pathway through computing. Even broad construals of “computing careers” such as user experience design and human-centered computing do not capture the wide range of interests students may pursue with computing knowledge and skills, such as creating art, teaching, contributing to policy making, participating in hobbies, and performing community work. The broadening of what constitutes a “computing career” may still be bounded in ways that center already dominant ways of engaging in computing, such as coding.

Further, the push to develop a “sense of belonging” among minoritized learners that does not expand narrow conceptions of computing can be counter-productive if the computing environments and cultures they will “belong” to fundamentally do not welcome, respect, or value them [28]. Therefore, it is as important to acknowledge, deconstruct, and reconstruct the norms and values contributing to the dominant narratives around computing in the long-term quest to create spaces where students can feel like they belong and do not need to diminish their identities and practices [29–31]. Our scholarly understanding of what it means to participate in computing is incomplete if it does not acknowledge and value the wide range of interests and goals students may pursue with knowledge of computing, including hobbies and community-building. Ultimately, this study builds directly on the idea that computing education is not about making learners into products who have market value because of their skills at coding or “thinking like a computer scientist.” Rather, it is an environment for working towards imagining multiple simultaneous uses and users of computing [33, 34].

3 THEORETICAL FRAMEWORK: FIGURED WORLDS

We use the figured worlds theoretical framework to examine computing as a social practice and analyze the experiences and perceptions of former BPC program participants. By social practice, we refer to how participation in computing can be understood as not only learning and engaging in a narrow set of practices, but also as sets of relationships to other people and to what computing is interpreted to be [32]. With this focus, figured worlds allow us to see elements of the social practice of computing. A *figured world* is “a socially and culturally constructed realm of interpretation in which particular characters and *actors* are recognized, significance is assigned to certain *acts*, and particular *outcomes* are valued over others” [4]. Many studies focus on the perceptions of the actors (computer scientists), practices (programming), outcomes (major/career in computing), or

artifacts (computers, circuits) of the dominant figured world of a career in computing. For example, when students are asked about their perceptions of computer scientists, they are drawing from knowledge of stereotypes of this group and giving us insight into how they see actors (computer scientists) in this figured world of computing [6]. In our work, we draw on this framework to explore how the participants' perceptions of the dominant actors, practices, outcomes, and objects of computing produce a figured world. We also explore how the participants situate themselves within that world and produce alternate worlds by examining the program outcomes they valued and their reflections on how their experiences with computing influenced their life trajectories.

Learners interested in computing come to understand their social position within a dominant figured world that is structured by white supremacist and patriarchal notions of who can succeed in computing [7–10]. While BPC programs share the common goal of broadening participation in computing, the approaches they use differ; some BPC programs do not aim to explicitly challenge dominant notions of computing and instead focus on providing learners opportunities to engage with the dominant actors, practices, outcomes, and objects of computing. Other BPC programs work to create *figured worlds* for learners to reinterpret the larger field of computing in ways that explicitly challenge white supremacist and patriarchal notions of who can succeed in computing. These programs are “worlds of possibility” where participants can create, imagine, and playfully engage with different ways of participating in computing [11]. A *computational perspective* [12] can be considered a “sense” of their figured world: “an expertise in the use of cultural artifacts, that may come to re-mediate their positions in them” [4]. This perspective is formed as they engage with computational artifacts in a way they previously had not [13]. In this work, we consider learners' *computational perspectives* as part of their figured worlds of computing, which is reflected primarily in how the data generation instruments were crafted.

The photo elicitation method, discussed in more detail below, was chosen to provide participants an opportunity to (re)present acts, actors, and outcomes in their figured worlds of computing, which also draws on the physical elements of figured worlds [14, 15]. Further, it allows us to structure the reflection that participants do as part of this study. Recognizing the actors, practices, objects, and outcomes that are part of the figured worlds of learners helps us see into what the learners experience as part of their computing education. Understanding their perspectives and experiences are vital to designing new and redesigning existing learning environments with a focus on equity and social justice.

4 RESEARCH DESIGN

This study was conducted in three phases: in phase 1, recruitment, we contacted, screened, and determined eligibility for each of the participants. After eligible participants were identified, they completed an additional survey that was used to understand more of their background related to their (1) demographics, (2) education, (3) activities related to computing, and (4) their participation in the program. In total, 11 of the participants completed the survey (Table 2). The survey responses were used to create (1) participant profiles that were referred to during the analysis, as well as (2) the “Program Contexts” section below. In phase 2, the participants participated in a reflective interview process that included a photo elicitation activity. Finally, in phase 3, we used a member-checking process that invited those who participated in phase 2 to comment on the researcher-generated themes and reflect on the anonymous experiences of others, which was used as part of the analysis. An overview of the overall participation can be seen in Table 1.

All our participants are adults, some almost a decade removed from participation in their programs that they participated in during their K–12 education. For this study, it is key that the participants were distanced by time from their initial experience. That is, we are aware that it would be hard, if not impossible, to say that these programs had any specific outcomes or direct impact

Table 1. Data Collection: Number of Participants for Each Stage

Program	Phase 1				Phase 2	Phase 3
	# Contacted	# Screening	# Ineligible	# Survey	# Interview	# Member Checking
A	13	8	0	6	7	4
B	7	4	1	3	3	3
C	6	4	1	2	2	1
Total	26	16	2	11	12	8

Table 2. Program Overviews

Prog.	Location	Year	#	Participant Demographics	Program Details
A	Texas	2017	7	Asian: 1 (14%) White: 2 (28%) Latina: 2 (28%) White-Asian-Middle Eastern/North African: 1 (14%) Undisclosed: 1 (14%)	• 5 days a week/7 weeks • High school girls • Teach Scratch, HTML/CSS, and Python, while also discussing topics around the role of computing in society and diversity, equity, and inclusion in computing
B	Georgia	2016	3	Black: 1 (33%) Black-Latina: 1 (33%) White-Asian-Native American/Pacific Islander: 1 (33%)	• Yearly, week-long summer program + school year • High school students • Java
C	Arizona	2009	2	Latina: 1 (50%) Undisclosed: 1 (50%)	• Weekly over the course of a school year • Computer literacy; Scratch + discussions around diversity, equity, and inclusion in computing as well as the impact of computing in society.

on their perceptions of computing so many years later. This being the case, we take the stance that there is something to be learned from how people, particularly those operating in the margins of computing educational spaces, say that it impacted their lives. Further, we view their participation in these programs as launching points for understanding what kinds of things can come out of participation. The span of years allows for many different influences, interventions, and events to occur that shape how people’s lives take place. Yet, having space to reflect on particular experiences allows us to begin to trace what kinds of learning, opportunities, and connections BPC programs can set learners up for later on in life.

4.1 Phase 1: Recruitment

Participants were recruited through a screening form sent to programs that met the following criteria: (1) focused on attracting women, non-binary, and gender non-conforming people, and Black, Latinx, and Native American people into computing, and (2) taught coding of some sort (blocks-based or textual). We ultimately recruited from three programs: Program A, which was taught by the first author and had a direct connection with the participants, and Programs B and C, who sent out emails to past participants with a screening form designed by the researchers. Participants were chosen based on their age (over 18), gender identity at the time of participation, and participation in the program. The overview of each of the programs who recruited and the participants is below (Table 1). To help keep the anonymity of the participants, we will not be using the actual names of the programs or participants in this article.

4.2 Program Contexts

Program A was led by a team of undergraduate students in computer science and IT/computing professionals. This was an independent summer program that lasted five days a week over seven weeks. This program is held at locations across the U.S., though this study focuses on one class in a major city in Texas in 2017. The goal of the summer program was to teach high school women how to code using Scratch, HTML/CSS, and Python, while also discussing topics around the role of computing in society and diversity, equity, and inclusion in computing. Three out of the seven (43%) of the participants who were interviewed had majored in computer science.

Program B was led primarily by undergraduate students in computer science and academic researchers in computing education. It was hosted yearly at a large public university in a major city in Georgia. This program is a week-long summer program tied into a school-year-long program where high school students were tutored and mentored by undergraduate students at the university. All students were in **Advanced Placement (AP) Computer Science A (CSA)**, which uses Java and is equivalent to a college first-year computer science course. Three out of the three participants (100%) who were interviewed majored in computer science.

Program C was led by K–12 teachers, academics, and technology hobbyists who do not use computing extensively for their job. This program was hosted in a high school in a major city in Arizona. Weekly over the course of a school year, students learned skills to develop their computer literacy as well as programming in Scratch. This program had discussions around diversity, equity, and inclusion in computing as well as the impact of computing in society. Neither of the participants who were interviewed majored in computer science.

4.3 Phase 2: Reflective Activity

To engage participants in reflective activities around their experiences, we employed photo elicitation interviews. We define “reflective activity” as exercises that engage the participants in thinking about topics via their past experiences. We focus in particular on learning about how they think about computing via BPC programs and ask questions that are meant to get them thinking about both in relation to each other.

4.3.1 Photo Elicitation Interviews. Photo elicitation interviews are structured or semi-structured interviews in which participants are asked to respond to and/or discuss photos to explore a specific topic [35]. The photos can come from many different sources (original, found, made, etc.) and can be provided by the researcher or the participants themselves. These interviews are often used when the subject matter of the interview is or could be hard to describe in words or to be able to discuss multiple perspectives that may not come up in a normal interview [35, 36, 38]. In addition, this method was chosen specifically for its affordances to represent the participants’ *figured worlds* of computing; that is, where typically figured worlds of STEM educational environments would typically be studied in an ethnographic manner [39], we can see a participants’ figured world retroactively as they reflect on the prompts. We utilized photo elicitation interviews here to both have a more concrete representation of the ideas we were talking about and to allow the participants to reflect on their responses before the interviews.

Implementation was in two parts; in part 1, we asked participants to collect photos that responded to prompts related to the research questions, and in part 2, we conducted a reflective interview based off of those photos. In total, 12 participants were interviewed for this study (Table 1). Interviews were an hour and a half and conducted over Zoom and took place over June–August 2020. The recordings were then sent to a transcription service for transcribing.

4.3.1.1 Part 1: Photo Gathering. We asked participants to prepare photos ahead of the interview by sending them a Word document via email containing the specific prompts and instructions for

Table 3. Prompts and Questions for the Photo Elicitation Interviews

Phase 1: Photo Gathering	Phase 2: Interview
Prompt	Prompt-specific Follow-up Interview Questions
Please bring at least one picture that answers this prompt: What is “computing”?	N/A
<i>Objects</i> : Please bring at least one picture: What are tools you use to participate in computing?	(1) How do you use these tools, or how do you think they are used? (2) How do you feel when you use these tools?
<i>Computational Perspective</i> : Bring a picture that responds to at least one of the four prompts: “With computing, I can ...” • ...express myself.” • ...ask questions of the world, including the tech I use.” • ...connect with other people.” • ...[blank so participants can fill in]	(1) [If they chose to write in an answer] Why did you choose to write one in? (2) [If they provided several] Which do you think is most relevant to your experience learning computing? Why?
<i>Actors</i> : Please bring at least one picture that answers this prompt: Who comes to mind when you think of someone who “does computing”?	(1) How would you describe this person? (2) Would this person have been different before you participated in this program?
<i>Practices</i> : Please bring at least one picture that answers this prompt: How can people participate in computing? What do people who participate in computing do?	N/A
<i>Outcomes</i> : Please bring one picture for each question: • How did you use computing before [program name]? • How do you use computing now?	N/A
<i>Social Position</i> : Please bring one picture for each question: • What was your role during the program? • How are you similar or different from other people in that program?	N/A

gathering the photos. The prompts were designed to elicit responses related to different aspects of a figured world: actors, outcomes, objects, practices, social position, and computational perspective. For example, the prompt “Who comes to mind when you think of someone who ‘does computing’?” (Table 3) was meant to elicit a photo of someone who participates in computing, relating to the actors of their figured world of computing. These prompts, while designed to be mapped to a particular part of a figured world, are intentionally broad and open-ended. They were designed to encourage the participants to think about what it means to them and how it could be represented in a photo form. In the interview phase, more specific questions were asked to be able to tie together how they think about the broad prompt in relation to their experiences as a computing learner. Each of the prompts were similarly worded (see Table 3, column “Phase 1: Photo Gathering”). After completing the activity, the participants uploaded their photos to a shared folder that allowed us to access their photos during the interview.

4.3.1.2 Part 2: Interview. We used the photos they uploaded in Phase 2 to conduct the photo elicitation interviews. We designed the interview to ask participants questions about what the photos meant to them, why they picked them, and what stood out to them. To start the interviews, we asked participants about their experience collecting the photos, if there was anywhere in particular they wanted to start off, and if they wanted the interviewer to share the screen with photos. If the participant wanted to talk about one of the prompts specifically, then the conversation started

there. If they did not want to talk about anything specifically, then the conversation proceeded in the order of questions below. If the discussion for one prompt led into ideas that were related to another prompt, then the discussion would move to that instead of following the order. For every prompt, the interviewer started with asking the following questions:

- (1) Can you tell me how you chose this photo?
- (2) What does this photo represent to you?
- (3) Why did you choose this photo in particular?
- (4) How does this photo relate to your experience in [program name]?
- (5) How does this photo relate to the prompt [recite prompt]?
- (6) What stands out most to you about this photo?
- (7) Is there anything else you want to share about this photo?

In addition to the general questions, the interviewer asked prompt-specific questions for select prompts where the general questions did not capture everything we were interested in. Examples of these questions can be seen in Table 3 under the “Prompt-specific Follow-up Interview Questions” column. These questions offer a deeper insight into how the broader prompts informed their thinking. For example, the prompt “What is ‘computing’?” for the original photo gathering stage may be too broad to connect back to a specific experience that happened several years ago. However, the prompt-specific questions guided the participants to connect their photos to their time in the program and the aspects of the program that influenced their perception of computing.

4.4 Data Analysis

The first author performed holistic coding [41] on the transcripts of all 12 interview participants, identifying 57 codes from this process. Following this round of coding, the two authors collaboratively grouped the 57 codes into 7 larger code groups using the code descriptions (Table 4). In the second round of analysis, we analyzed the transcripts using the 7 codes and produced memos that focused on understanding each of the participants’ experiences. After the second round of analysis, the two authors discussed shared themes across the participants’ experiences. The process of focusing on individual experiences followed by an analysis of shared experiences allowed us to understand each of the 12 participants in relation to one another while still honoring their individual ideas and experiences. To incorporate respondent validation in the study design, we used a member-checking process to discuss the 7 code groups and sample excerpts with participants. This is aligned with analysis methods that seek to construct knowledge from data [2, 40], which both takes into account the relationship between ourselves as well as the participants to reduce the effect of our own preconceptions about their experiences on the findings. However, we do not deny our backgrounds have not informed our theoretical sensitivities brought to this work.

4.4.1 Member Checking. We used member checking to shape the analysis and ensure researchers’ perspectives were not the only ones included. Member checking is connected to a constructivist approach, because it brings the participants into the construction of meaning from the data [42]. In this study, member checking was conducted through two steps. In the first step, participants read anonymized quotes from other participants that had been pre-selected by the researchers because they represented one of the 7 code groups. The participants were asked to describe the quote using a word or phrase (a code) and prompted to explain the rationale for their choice. The words or phrases chosen by the participants were compared to the researcher-generated codes and code groups. In the second part of the member-checking process, we shared the 7 code groups and their corresponding descriptions with the participants. They were asked what their reactions, interpretations, and overall impressions of the code groups were, and their

Table 4. Code Groups, Related Codes, Code Group Descriptions, and Member-checking Feedback

Code Group	Related Codes	Description	Member-checking Feedback
Computing Identity	“creator of”; “i’m not a normie”; “i’m not the logical person”; “not becoming”; “user of technology”; computing identity; confidence; talking to others about computing; who participates in computing?	Participants talk about how they relate to their larger sense of what computing is and how they participate in it.	“Hegemonic Computing” was confusing in general, because it could be an umbrella for many of the experiences that were discussed and was primarily confused with “Computing Identity.” For the analysis, we categorized excerpts where participants talked about distinctions between a “common understanding” of computing and who participates in it under “Hegemonic Computing,” and under “Computing Identity,” we placed excerpts where participants discussed how they related to computing, now and throughout their lives.
Hegemonic Computing	“public-facing computing world”; what is computing?; coding; digital natives	Participants talk about how computing is perceived broadly or what the dominant understanding of computing is and who shapes it	
Computing Trajectory	“put me on that path”; family; gender differences	Participants talk about factors that influence path through computing	Most feedback about this theme was its distinction between this and “Computing Trajectory,” namely, that it seems they are interrelated. For the analysis, we categorized excerpts where participants talked about characteristics of someone who “does computer science” under “Expansive Computing,” and under “Computing Trajectory,” we placed excerpts where participants discussed how they moved from one point to another in their journey.
Expansive Computing	Collaboration; creativity; design; problem solving; puzzle	Participants talk about things that make you successful at computing that are not necessarily knowledge of programming/computers	
Computing, Demystified	“some sort of fairytale”; shift in perception; “Eye-opening”	Participants indicate parts of computing that were not clear to them before the program they have since understood in a new way	
Learning environment	algorithms; community; competition; experience in program; leadership; mentorship; role in program; social justice; learning computing; resources	Participants describe the learning environments they have been in related to computing	
Use of Computing in Practice	computing as a hobby; computing as a job; computing as helpful for other interests; how to participate in computing; impact of computing; teaching; tools to participate in computing; use of internet; working with tech; computing for school	Participants describe the ways they use computing in their daily lives	

responses were factored into our evaluation of the code groups as meaningful units of analysis. We invited all participants to take part in the member-checking process, and 8 out of the 12 responded (Table 1). Their responses were recorded in a shared document, which they could also edit and comment on. Since each was shared individually, they could not see each other's responses to the information on the document.

Member checking informed the overall analysis in two ways: Participants shared their thoughts on how the representative quotes could be interpreted, expanding our interpretation of the quotes themselves, as well as their thoughts on the themes we generated from the coding process. Some participants said the researcher-generated themes matched what they said, though more “academic” or “professional,” and others said the researcher-generated themes were not similar to their own but could also be valid. In Table 4, we show examples of participant feedback changing how we defined the theme and what it included, using the themes that most changed from the initial document.

4.4.2 Collaging. After the member checking, we created collages of the photos participants shared during the photo elicitation interview. The aim of creating collages was to support the coded excerpts and to have anchoring artifacts that we could return to during the narrative construction of our findings. In the process of creating the collage, we tried to construct an image of their perceptions of computing by sizing and placing photos together in ways that reflected what the participants had shared in the interviews and member-checking process, so the collage could represent their perceptions of computing and the dominant actors, practices, outcomes, and objects of computing that contributed to their figured world. Ultimately, the collages were used to help tell the narratives participants shared in the findings [43] and are part of a constructivist approach to data analysis because of the way that we (the researchers) are visibly “constructing” the participants’ responses through our own lens.

4.4.3 Positionality. At this point, it is useful to briefly explain our relationships to this line of inquiry. We both approach this work as Latinx people conducting research within an R1 institution. Additionally, we share experiences as researchers and learners of computing. Given this, our research centers the experiences of marginalized computing learners. Though we have different specific life experiences, these lenses inform our analysis by allowing us to bring into focus how people marginalized in computing can still value their participation.

5 FINDINGS

The findings highlight the experiences of three participants, one from each program. These participants were selected to illustrate the breadth of experiences following the programs they participated in, and each illustrates a selection of the major themes that came out of our data analysis and member-checking stages. The chosen examples were narrowed down based on a few criteria: (1) each participant was in a different program, (2) each participant had a different choice of major, with at least one following a traditional computing path. Given that both participants from Program C did not major in computing/computer science, and all three from Program B did, the participant from Program A was chosen because she represented a “middle ground” because she started with a major in computer science and switched later. Giving an in-depth account of each of their stories’ foregrounds each participants’ experiences to provide an illustration of their perceptions of computing and how those perceptions align or misalign with the program outcomes they valued, rather than trying to generalize across their experiences. We place these perspectives in conversation with each other to spark a new imagination for future computing education research, while acknowledging this process is necessarily limited in its ability to cover every new possibility presented by the participants.



Fig. 1. Collage of Miranda's pictures.

5.1 Miranda: "I Still Use What I Learned to This Day."

At the time of the interview, Miranda was an elementary English teacher in Arizona. She is a Latina woman and majored in Transborder Studies at a major public university in Arizona. She participated in program C as a student from 2009–2011 and was a program mentor for two years while in college. She found her way to program C coincidentally when her math teacher mentioned it as an opportunity in class; Miranda and her friend signed up because it seemed fun. She still uses some of the skills (Scratch and video editing) she learned in program C. She makes videos for an array of different occasions, from professional training for work, to her own personal videos for sharing her experiences.

Miranda perceived computing as an avenue for solving problems. She described computing as the "use and operation of computer technology that can help us solve any problems or help us create new solutions." Figure 1 is a collage of the photos Miranda brought to the interview. Two of the images she brought were repeated for different questions, one of a woman holding her phone and working on the computer, with a coffee on her desk, and one of a snapshot of the video editing software she uses for her job and hobby (center, layered). She focused on representations of her students, such as the male coder with a hoodie on the right center and the computer lab on the top right of the collage. However, she also discussed how those photos did not align with how she perceived computing, particularly the representation of coders as males with hoodies; she constructed an alternate representation of coders by ensuring photos of people working on computers or hardware (e.g., bottom right) were people of color. She defines this as a concerted effort on her part to challenge the images that come to mind of who participates in computing. From these photos and the resulting collage, we have a window into Miranda's *figured world* of computing. It includes actors who are of various races, ethnicities, genders, and ages, and practices

that run the gamut from coding to typing. The object of the computer factors in prevalently, yet so does a cup of coffee. This shows how computing is just as much about the act of using a computer as it is the social environment around it, which may call for a cup of coffee.

Miranda viewed participation in computing as associated with the ability to write code and use technology. In response to the question, “*How would you define what a computer scientist does?*” Miranda responded: “Solve problems using technology. Write and program new software we can use. Create new apps everyone can be able to use.” While her perception of what a computer scientist does includes dominant practices such as writing new software, she also shared that the vision she shared surfaced her own struggles with how she views her own position within the figured world of computing. She shared, “it’s taking me time to unlearn what I learned all my life,” referencing how she is “unlearning” all the stereotypes she associated with computing. She does not take on the title of someone who participates in computing, because she feels that, since her skill of video editing does not involve coding, her credibility as someone in computing might be questioned. Her unwillingness or inability to view herself as actively participating in computing points to how she views the practices of the dominant figured world of computing as incompatible with her interests and current career.

Yet, while she does not view herself as someone who fits within the narrow perception of what it means to participate in computing, she articulated an alternative vision of the program outcomes she valued. When reflecting on how her experiences in the program influenced her life, she described how she leads professional development sessions for other teachers on using technology in the classroom, creates videos, and integrates Scratch into her English curriculum, all choices or activities motivated by her participation in Program C during high school. She credits her ability to teach others as something she picked up in the program, which developed her leadership skills in relation to technology: “I wouldn’t be helping the other teachers at my school if it wasn’t for [Program C]. I have confidence in my technology abilities and that practice of helping others because of [Program C].” Her active role as a trainer for other teachers and view of herself as someone who can experiment with visual programming (Scratch) in the classroom aligns with the description of herself as a “leader” in the program.

When reflecting on her role in program C, Miranda said, “We would all help each other... but also it was different in the sense that maybe I started just feeling more of a leader. I was more outspoken. I was presenting more or volunteering to present more.” These presentations allowed her to develop her confidence in her communication skills as well as technological know-how. During a final project of the program in her first year, she described presenting to a group of “lawyer-looking people” about a virtual design for a clinic she worked on for the survivors of domestic abuse: “[A]t the end of the presentation, they tell me, ‘Wow, that’s the technology that we use.’ [...] And so to think like, ‘Wow, I’m presenting to these lawyer-looking important people at age of 15, and yet they’re astounded by me. That’s super cool.’ And it starts helping you with your self-esteem in terms of your capabilities like, ‘I can do this.’” This was one of “the life pivotal changing moments” for her in terms of what she thought she could do with computing and impacts her confidence to explain things to others to this day. Though this was a skill she developed as part of a computing education program, Miranda does not necessarily see it as part of what the actors of a figured world of computing do.

When talking about why she chose not to major in computer science, “fear” that she would not do well in the major was a key factor. For instance, when making her decision of what to major in, as a first-generation college student she wanted to do something she felt she could manage, like teaching. “I feel like one of the main reasons that I didn’t [major in CS] was just fear. It was fear of, ‘I’m not going to be successful at computing, computer science if I major in that.’” She also mentioned that being the first person in her family to go to college contributed to this fear,

saying she “didn’t want to try it and then fail and not succeed. And it’s like, I felt maybe teaching was more like a safer bet.” However, she did not view this decision as closing off the possibility of engaging with computing more later: “I thought to myself I think at the time, ‘I’ll just do teaching for now and then I’ll get back into it later and see what else I can do.’” Given the opportunity now, she would go back and learn data science or something similar: “I am not as afraid, but it’s still that feeling of, ‘Well, you might fail.’ But that doesn’t mean that I won’t try it. Yeah. It’s still open. It’s still open.” Even if she could go back and change what she did, she does not say she would automatically change her decision but wished she had known what options were available to her as a student, such as double majoring or minoring in computer science. In Miranda’s case, her decision to not pursue a computing degree was based in fear not of the subject itself, but on what would happen if she “fails” to become successful in this area. Although she was exposed to programming as a student and had access to diverse role models involved in computing, she was still afraid to pursue computing via the traditional route of majoring in computer science. Instead, she carved her own form of participation out of what she learned in program C through being a “creator of” videos and lessons for her students to express themselves on Scratch and keeps her options open for learning new things in this area in the future.

5.2 Angelica: “I Just Decided it wasn’t for Me”

At the time of our interview, Angelica was a Latina third-year student at a large university in Texas who recently switched majors from computer science to business. She started her trajectory in computing with classes in high school, which her dad encouraged her to sign up for. Her cousin participated in Program A the year before Angelica, and when her cousin had a positive experience Angelica’s dad encouraged her to participate as well. When she went to college, she still was not sure about what to pursue as a career or major, so she picked computer science, because she perceived it as the route that would offer the most career options: “I still to this day don’t really know what I want to do [...] That’s a reason why I kept an open mind for this program too, because I was like, ‘Oh, there’s so many things you can do within it.’” She ultimately decided to switch majors because she felt the process of working on “apps and robots” was not giving her what she needed in terms of human interaction. She is still trying to figure out what she wants to do as a career, but knows she wants to do something people-oriented.

When asked about her perception of computing, Angelica defined computing as “the use of computers to complete tasks more efficiently.” She elaborated on her perception when describing the photos she chose because they centered the use of technological devices, saying “I put that picture [of the devices] as well, because [someone] could know how to code and be a computer scientist, or they could just be, like I said, an everyday person.” She further builds on this by adding: “The majority of people, whether it’s computer science or just a person that uses the internet, you have those devices.” The use of technological devices is what she centers as computing, and it can be done by anyone, anywhere. Figure 2 is a collage of the photos Angelica brought to the interview. The photos she brought focused heavily on devices and how they enable connection. In the bottom center is an image of two children who are using devices, and the images surrounding them in the collage represent ways and tools someone can use to participate in computing: screens that have a lot of code are incorporated with photos of Scratch and hardware.

As someone who switched out of the CS major, her perception of computing includes objects such as devices and end-user applications that allow people to connect to each other and to information. She highlights “you can be fulfilled on [the] news” through “googling it” when you feel you did not get “the full story,” which is “an everyday aspect” in which people can participate in computing. Being able to access the internet to connect with relevant people and sources of information is something she considers part of computing, although it is not what was part of the



Fig. 2. Collage of Angelica's pictures.

curriculum she had as a computer science student. The *figured world* of computing she experienced valued a narrow set of practices with computing, which ultimately contributed to her decision to switch out of the computer science major.

Angelica also described what a computer scientist does as “codes apps, websites, machines, [and] automatics.” She views someone who typically participates in computing as someone who follows a narrow, preset path that includes a degree and ultimately a job in computing. When she reflects on why she chose to pursue computer science, she mentioned that she “decided to go with it, because obviously it’s also a really good major to do anyways, [...] It’s not something that’s going to go out of date [...] But it’s like you can never be in trouble with that. There’s always going to be job opportunities.” This statement highlights how the dominant perception of computing, that it is used to get a job, was how she saw the endpoint of completing the major. Angelica felt conflicted about viewing computing as a career pathway because her role models in Program A, who were women working in computing, described hostile and socially isolated work environments. Taken together, she decided those conditions were not something she wanted to work against in her life. This gives us insight into how the perceived common practices of the dominant figured world of computing can lead to people not engaging with other aspects of computing that may otherwise be interesting to them.

Despite no longer being in the major, Angelica views her experience in Program A as helpful and something that still benefits her to this day. She stated that she “obviously” does not code anymore but discussed the photo of the YouTube logo and identified multimedia making as how she participates in computing now. She stated that YouTube has been a huge factor in her educational and hobbyist pursuits. She also discussed social connection as a program outcome she valued

and described how she made connections to other people that have helped her through college, including her college roommate, whom she met in Program A. The relationships she built through her participation in computing outlasted her decision to major in CS. Although she decided to change majors, she describes still valuing the opportunity to make friends and try out computing: “Deep down I always kind of knew it really wasn’t the thing for me, but I also just wanted to try it out. Because that’s kind of badass.” Given her social inclinations, part of why the CS major did not resonate with Angelica was how little it showed the opportunity to interact with others as part of a possible career. Ultimately, she rejected a traditional career in computing because of this limited opportunity to interact with others. However, she does not need to feel like she is part of the traditional field of computing to see ways to participate, such as when she identified the many ways she uses technology/computing to enhance her daily life.

In her reflections, Angelica identified that she valued making friends and bonding over the experience of learning to program together as important outcomes of her participation. She described being drawn to computing education programs in high school because she viewed them as places where she was able to meet up with friends and develop new connections. This figured world she developed in high school changed as she went into the major at a university. However, the connections she made while participating in Program A were instrumental in her transition to college life, because she is still friends with them and “most of [them] were all engineering at that point, but I would be able to study together and just make those connections that I definitely wouldn’t have had otherwise.”

5.3 Deidre: “I was Thinking of the People I Know Who do Computing and are a Good Example of Being Capable but Also Kind”

At the time of this interview, Deidre, a Black woman, was a senior in computer science at a STEM-focused public university. She started off her journey in computing by taking AP CS A as a senior in high school and signed up for program B because she was learning the content for the first time and wanted to have the extra help. At the time, she did not know how much of a “minority” she would be in computing, because her classroom teacher was a Black woman. This was something she reflected on during her interview, saying she “didn’t really appreciate what a super-duper minority I would be in computing because that year, when I started in high school, I didn’t stand out anymore than any of my other classes, than any of the other stuff I was doing.”

Deidre defined computing as “a field encompassing making computers and computer programs that help advance the world in some way.” In the interview, she elaborated on this definition, saying “to me, computing really is just about people working together on computers to solve problems.” She mentions that she brought the photo of hackathons for this reason, because it is “where everyone’s just sitting in front of a computer working on a problem because that, in essence, that’s kind of what it is. You’re using a computer kind of as your tool to solve something.” Figure 3 is a collage of the photos Deidre brought to the interview. Most of the photos she brought were originals she took at different times in her life. Notably, none of the photos she brought used code as central to the image. This is a departure from the representations of computing seen from Miranda and Angelica, who both include code prominently in their representations of computing. In contrast, Deidre focuses on the people and the ability to connect to others with/over computing. Along the bottom of the collage (Figure 3) are images of people and places she associates with computing; from bottom left, images of a hackathon she had participated in and mentored for, then a photo of Deidre and her roommates sitting on the steps of the house they rented for a software engineering internship they did in San Francisco, then a view from the window by one of her friends’ desks, and in the bottom right two of the people who lead change as leaders of the teaching assistant group Deidre participated in.



Fig. 3. Collage of Deidre's pictures.

When talking about her interests, she described wanting to work on things that are “tangible,” mentioning there are some parts of computing she does not want to do: “They’re not going to catch me writing scripts, full-on data things. I like things that are tangible. I like making things that are tangible.” The “tangible” projects can be things a person can interact with, like an app. Her quote illustrates how broadly she understands the field of computing to be, bringing attention to the divides between work that is “tangible” and “intangible” or more theoretical. Her figured world of computing is expansive, including the social connections she has made with those she also considers “actors” of figured worlds of computing.

Deidre’s experience in the program inspired her to not only pursue CS, but also to come back to the program as a mentor. She describes her decision to mentor other students as motivated by “being in a position to help someone else.” After majoring in CS for a year, she described understanding there are computing concepts others can get “caught up on” or struggle to understand. Mentoring served a dual purpose for Deidre; she was able to identify her own knowledge gaps by “reflect[ing] on the things you still don’t understand” as well as help others who were struggling to learn computing concepts. The ability to go back and be a mentor for the program that supported her own educational journey in computing aligned with her values and was a personally meaningful outcome of her participation.

This attitude about the importance of mentoring was with her throughout her time in college, as she also served as a mentor for hackathons and as a teaching assistant for different CS courses. When she thinks of people who participate in computing, she thinks of her peers who she TA’d with and describes them as people who are “capable and kind.” In Figure 3, the two people she says exemplify the “capable and kind” characteristics can be seen in the bottom right corner. Even in the photo, the people are striking a balance between being silly with the other TAs (especially Deidre,

who took the photo) and still being in a leadership position, sitting at the podium in a lecture hall. This was an important distinction for her, especially for mentors, since many people she has encountered in school have not been as kind as they are capable, although this is something she has encountered in her experience with mentors in industry. This view calls attention to the fact that, within a figured world, the practices people enact that are valued are not always those that are the most supportive of others.

Deidre began to feel like a “super-duper minority” in computing when she enrolled in college and took large introductory computing courses. She shared, “I had started college [and it] dawned on me a little bit more. There’s large freshman lecture classes. I was like, ‘Oh, this is what it means when they said underrepresented. They meant really, really, really.’” Yet, instead of dropping out of computing, she recognized how her own experiences could help her be a mentor to young students of color and women: “I still felt so similar and connected to them because I was like, ‘I was in your shoes a year ago.’” Her newly gained understanding of underrepresentation in computing coupled with her positive experiences in Program B motivated her to become a mentor: “[Mentoring] was just a really, I feel, important experience. [...] Being able to help someone else through it because you’re like, ‘I know it feels this way right now. I felt that way a couple of months ago. But we can sort of work through it.’”

6 DISCUSSION

The findings address the two **research questions** for this study: (1) How do women who participated in BPC programs describe their perceptions of computing? (2) How do those perceptions align or misalign with the program outcomes they valued? Miranda, Angelica, and Deidre present many insights on these questions, which can help further our understanding of the role of programs that aim to broaden participation in computing by engaging marginalized students. Only one of the women profiled here, Deidre, “persisted” in computing in the traditional sense, by pursuing a career in computing and working on a major in computer science. However, the programs still played an important role in the lives of Miranda and Angelica, because they were an opportunity to learn new skills and find out what they were interested in. In the following sections, we discuss how the participants’ perceptions of computing illuminate important tensions around the purpose(s) of computing education.

6.1 What Does it Mean to be a “User” or “Creator” in Computing?

Defining what computing is and what computer scientists do is an important point for entering into conversations about why it is important or how one can relate to the field. No two people in this study think of or represent computing in the exact same way, although there are some themes that arose across participants such as describing computing as the act of *using* a computer to “solve any problems,” “advance the world in some way,” or to “complete tasks more efficiently.” While Deidre also does call attention to “making” computers as part of computing, it is important to note across the board “using” computers is an important part of their definitions of computing. This adds a layer of nuance to existing work in pushing for students to not only be “consumers” or “users” of technology and computing [32] but to be “producers” and “creators” of it. Namely, participants’ responses all call attention to what the end goal of using or making the computing technology is. Further, Miranda describes herself as a “creator of” technological artifacts (her videos), though this use of computing is often interpreted as being a “user” of, and thus less valuable to include as a participant in computing. This point builds on Weidler-Lewis et al.’s [32] idea of taking a “social practice” view on computing and who participates in it to expand participation. That is, participation in computing is much more about how people relate to computing and others in it than it is about participating in narrow activities such as programming for working with hardware.

6.2 Depictions of Coding and Coders

Across all 12 of the participants, depictions of code and people coding (or who were perceived to be coding) played a large role. However, as is illustrated by Miranda, Angelica, and Deidre, their weight in their reflections on computing is different. Deidre, who is taking a more traditional path through computing, does not present code in her photos at all, while both Miranda and Angelica view it as playing a major role. This trend appeared across the 12 participants; those who pursued computer science as a major included depictions of code or “coding” (a person sitting in front of a computer with code explicitly on the screen) less than those who were not pursuing or did not complete computer science degrees, though some participants who were CS majors did include it to a lesser extent. Deidre’s narrative gives us some insight into why this could be: As she progresses through her college major, she sees more and more the importance of being able to plan out what the code should do and being able to explain it to others. The two images of whiteboards she brought illustrate this as well, since the whiteboard process (“whiteboarding”) was crucial to her as she collaborated with others and planned her work. This process is central to her work as someone on the traditional path, yet “whiteboarding” is not something any of the participants mentioned as part of learning how to code, until they got into advanced courses in college. Future exploration into this point can be explored as part of the design of a learning environment where learners engage explicitly with the process of “whiteboarding” before they start programming.

6.3 Moving Beyond a Sole Focus on Technical Acuity

There are a few ways participants present how they think about their participation in computing and its relationship to the programs they participated in. For example, Angelica does not consider herself to participate in computing, because she is no longer a computer science major. However, the program and classes she took played a major role for her to explore her interest in the field and was a place where she made friends that she has to this day. In a figured world, learners will attach significance to some acts and not others: Although Angelica was learning to program (which is a key academic outcome), she attached more significance to developing friendships. In her figured world of computing, the social acts of making “new connections” and “study[ing] together” were program outcomes she personally valued. Importantly, the social outcomes were carried on beyond the program and into her broader educational experiences in college.

Building on Angelica’s narrative, Miranda’s experience with developing her leadership skills related to computing was crucial for the work she does today. As she participated in Program C, she became “more outspoken” and volunteered to “present more.” Thus, through her increased participation, Miranda begins to see herself in a different light, as someone who is capable of leading and making significant contributions. She was able to develop leadership skills based on the way the program allowed her to show her expertise and help others. The leadership skills she developed in the program persisted into her career, and she continues to grow and share her expertise on using technology in the classroom.

Finally, examining Deidre’s emphasis on being “capable and kind” as part of the skillset of someone who participates in computing is important, because it highlights one’s ability to help others as being equally as valuable as their technical skills. She started off in Program B as a student and then decided she wanted to be a mentor for the program when she entered undergrad. As she continued her journey in college, she gravitated towards people who were also interested and able to teach others computing and considers that skill as integral to what it takes to participate in computing. This is something not often considered as an outcome of students’ participation in computing education programs, yet it played a major role in how she thinks about computing.

One of the key implications of these narratives is in the design of computing learning environments. That is, we should take into consideration what we anticipate the social or other

non-cognitive outcomes of their participation *could* or *should* be. A narrow focus on designing only for what *content* students should learn ignores the fact that there are many other things students are learning within any given context.

6.4 Expanding Computing Pathways Beyond a Computing Career

As learners reflect on their interactional experiences, they assign significance to particular acts or practices [11]. BPC programs may narrowly assign significance to computing by primarily focusing on the field as an economically valuable career pathway. Yet, prior research identifies honoring and integrating communal values as crucial to promoting a sense of belonging among learners underrepresented in computing [4]. Deidre's reflections reveal computing had *social* significance that aligned with her values of community-building and "being able to help someone else" with empathy and encouragement.

Both Miranda and Angelica mention in their interviews the credential of a degree in computer science is an important part of what makes someone a "computer scientist." Angelica outlines the pathway that lies before her, should she decide to pursue a career in computing: She would take the high school courses, complete a CS major, and get a job programming. She also knew from the experiences shared with her in Program A that this would be no easy thing, especially as a woman of color. Program A, while exposing her to the realities faced by women in computing careers, still did not have the effect of broadening what she could possibly do with the skills she learned there. Her perception of computing being "making apps and robots" with low social interaction and a high chance she would experience hardships due to her identity turned her away from that path. This is despite the fact she has skills that could be aligned with using computing, such as a desire to make a difference in the world, socialize with others, and programming.

Notions of participation in computing that value a narrow set of career interests and positions (such as software engineering) serve as a form of gatekeeping and overlook other meaningful forms and outcomes of participation. For example, Miranda, who did not complete an undergraduate degree in computer science, does not see her participation in computing as something that is determined by her degree. She employs many of the skills she learned in her program in her job as a teacher and in her hobby making videos. Her identity as someone who participates in computing is constantly in question, because she does not have the recognized credentials. Yet, her form of participation and persistence is important to her and is overlooked when focusing on just an interest in a computing career. People engaged in teaching computing or using computational tools can count as part of the wider computing community, depending on how it "is defined and by whom" [32]. With this in mind, it is important to design programs to ensure these many interests and end points [5] are valued.

6.5 Limitations

This study represents a small subsection of women who participate in BPC programs nationally and year-after-year. Miranda, Angelica, and Deidre offer us important insights into how narrow conceptions of participation in computing can have unintended consequences on participation, yet we would not claim their experiences necessarily generalize across all women who have ever participated in a BPC program. Indeed, even within this study each of the 12 women we interviewed has had a different experience before and since their participation in a BPC program. Additionally, there may be some bias in who decided to share their stories, in favor of people who had positive experiences in the programs. However, this work can be considered a starting point for future research to envision alternative conceptions of participation. Although unique, their experiences are not so siloed to make it impossible to identify themes across their experiences, and from the analysis of their interviews, we were able to identify some that we build on deeply

by focusing on three participants. Ultimately, there is still more work to be done to see how these themes may or may not generalize to a wider cross-section of BPC participants.

Given the temporal distance between the person we interviewed and the person that participated in the program, only so much can be said about the “actual” outcomes of the programs (e.g., is their perception of computing from this program or another experience?). We therefore position the reflective activities participants did as part of this research as creating a trace of what we can understand to be as an “alternative endpoint” of participating in computing. Put another way, we cannot (and do not) attempt to claim the participants’ entire perception of computing is solely shaped by an educational experience they had many years ago. Instead, we place emphasis on how they interpret their experiences since that time and how it might still be something that influences them to this day. This perspective emphasizes that no matter what, or how much, or in what ways, educational experiences impact learners that can have ripple effects across their lives.

6.6 Implications & Future Work

Across participants’ stories, we can see how computing education can have broader impacts on young women than their interests in computing careers. They take up the knowledge they learn in these spaces in different ways; sometimes, it is not the knowledge they take away but the connections they made in those contexts that matter to them as they live their lives. The implications of taking this view on their stories and perceptions of computing can be most directly seen in how we design and redesign future programs for learners of all backgrounds. Certainly, engaging students in learning about technology, programming, computational thinking, and so on, will continue to be a focus of computing education. However, the “soft skills” and community development that are currently considered as incidental learning or relegated to the realm of informal/BPC programs, such as leadership and activism, pro-social activity, appreciation of diversity, and ability to relate and communicate with others, should also be taken up more substantially in the design of computing learning environments as equally vital to students’ learning in these spaces. Further, this will allow us to consider a wider range of participation in computing, because the desired outcomes of participation will no longer center on how technical knowledge can be wielded most efficiently, but how learners can use their knowledge in ways that consider their own interests, communities, and contexts.

Future work in this area could expand upon these implications in a few ways, namely, (1) designing and assessing a program that explicitly attends to the social developments of teaching computing and (2) closely examining how dominant narratives of participation in computing shape learners’ experiences with computing education at various levels. While doing this, it will be crucial to consider how learners of various (dis)abilities, socio-economic, gendered, and racialized backgrounds are able to participate in these programs so their experiences can also shape future designs.

7 CONCLUSION

The role of computing and computing education in society is constantly in flux. Whether to grow a workforce, increase technological literacies, be a place for expression, or something else entirely, we, as researchers, educators, and advocates for computing education need to be reflecting on *who* gets to decide *why* computing education is important [43]. Part of this work is to ask *how* computing education has been important to people who have already experienced a part of it. To this end, our study presents cases of women who participated in informal, women-focused, computing education programs that taught computing and how it impacted their trajectories and thinking about what computing is and what it can be used for. As Miranda, Angelica, and Deidre reflect on their experiences with computing through photos and personal narratives, they provide

important insights into how dominant framings of why computing education matters can limit how participation in computing is recognized. The reflective interviews help nuance the existing work on perceptions of computing to parse out the different dimensions of a perception of computing. Their perceptions of computing are complicated and varied; this increases our understanding of how computing education can matter to people, even when they do not follow traditionally recognized pathways through computing.

Therefore, in this article, we discuss how participants' narratives raise points around (1) how common depictions of coding and coders matter, especially across CS majors and non-majors, (2) why it matters to be a "user" or "consumer" of technology, (3) moving beyond a focus on technical acuity, and (4) expanding the possibilities of what people can do with computing and what is considered part of computing. Taken together, the insights we see from participants can help inform the design of future programs by changing how we think about the rationale and values [3] that go into them, how we think about the social development of learners, and motivate future research into how programs can promote different types of participation in computing that do not center workforce and economic demands [44].

REFERENCES

- [1] J. J. Ryoo, T. Tanksley, C. Estrada, and J. Margolis. 2020. Take space, make space: how students use computer science to disrupt and resist marginalization in schools. *Comput. Sci. Educ.* 30, 3 (2020), 337–361. DOI: <https://doi.org/10.1080/08993408.2020.1805284>
- [2] N. Sankofa. 2022. Participatory thick descriptions: A collaborative and reflective approach. *Qualitat. Res. Psychol.* (2022). DOI: [10.1080/14780887.2022.2090469](https://doi.org/10.1080/14780887.2022.2090469)
- [3] R. Santo, S. Vogel, and D. Ching. 2019. *CS for What? Diverse Visions of Computer Science Education in Practice*. CS-forALL, New York, NY.
- [4] C. M. Lewis. 2017. Good (and Bad) reasons to teach all students computer science. In *New Directions for Computing Education*. Springer, Cham. DOI: https://doi.org/10.1007/978-3-319-54226-3_2
- [5] D. Holland, W. Lachicotte Jr, D. Skinner, and C. Cain. 1998. *Identity and agency in cultural worlds*. Harvard University Press, Cambridge, MA.
- [6] M. Tissenbaum, D. Weintrop, N. Holbert, and T. Clegg. 2021. The case for alternative endpoints in computing education. *British Journal of Educational Technology*, 52, 3 (2021), 1164–1177. <https://doi.org/10.1111/bjet.13072>
- [7] J. Hur, C. E. Andrzejewski, and D. Marghitu. 2017. Girls and computer science: Experiences, perceptions, and career aspirations. *Comput. Sci. Educ.* 27, 2 (2017), 100–120. DOI: [10.1080/08993408.2017.1376385](https://doi.org/10.1080/08993408.2017.1376385)
- [8] M. Ross, Z. Hazari, G. Sonnet, and P. Sadler. 2020. The intersection of being black and being a woman: Examining the effect of social computing relationships on computer science career choice. *ACM Trans. Comput. Educ.* 20, 2 (2020). DOI: <https://doi.org/10.1145/3377426>
- [9] J. Wang, S. H. Moghadam, and J. Tiffany-Morales. 2017. Social perceptions in computer science and implications for diverse students. In *Proceedings of the ACM Conference on International Computing Education Research (ICER'17)*. Association for Computing Machinery, New York, NY, 47–55.
- [10] A. Solomon, D. Moon, A. L. Roberts, and J. E. Gilbert. 2018. Not just black and not just a woman: Black women belonging in computing. In *Proceedings of Research on Equity and Sustained Participation in Engineering, Computing, and Technology (RESPECT)*. 1–5.
- [11] J. O. Thomas, N. Joseph, A. Williams, C. Crum, and J. Burge. 2018. Speaking truth to power: Exploring the intersectional experiences of black women in computing. In *Proceedings of Research on Equity and Sustained Participation in Engineering, Computing, and Technology (RESPECT)*. 1–8.
- [12] L. Urrieta. 2007. Figured worlds and education: An introduction to the special issue. *Urban Rev.* 39 (2007), 107–116. DOI: <https://doi-org.proxy.lib.umich.edu/10.1007/s11256-007-0051-0>
- [13] K. Brennan and M. Resnick. 2012. Using artifact-based interviews to study the development of computational thinking in interactive media design. In *Proceedings of the Annual American Educational Research Association Meeting*.
- [14] K. A. Searle and Y. B. Kafai. 2015. Boys' needlework: Understanding gendered and indigenous perspectives on computing and crafting with electronic textiles. In *Proceedings of the 11th annual International Conference on International Computing Education Research (ICER'15)*. Association for Computing Machinery, New York, NY, 31–39. DOI: <https://doi.org/10.1145/2787622.2787724>
- [15] S. Hladik, M. Shanahan, and P. Sengupta. 2020. Improvisational Infrastructuring by facilitators in public computing. In *Proceedings of the 14th International Conference of the Learning Sciences (ICLS): The Interdisciplinarity of the Learning Sciences*. 807–808.

- [16] P. Sengupta and M.-C. Shanahan. 2017. Boundary play and pivots in public computation: New directions in STEM education. *Int. J. Eng. Educ.* 33, 3 (2017), 1124–1134.
- [17] S. Cheryan and A. Master, and A. Meltzoff. 2015. Cultural stereotypes as gatekeepers: Increasing girls' interest in computer science and engineering by diversifying stereotypes. *Front. Psychol.* 6, 49 (2015). DOI: [10.3389/fpsyg.2015.00049](https://doi.org/10.3389/fpsyg.2015.00049)
- [18] T. J. Weston, W. Dubow, and A. Kaminsky. 2019. Predicting women's persistence in computer science- and technology-related majors from high school to college. *ACM Trans. Comput. Educ.* 20, 1 (2019).
- [19] S. Y. Schoenebeck and A. Bruckman. 2007. What is computing?: Bridging the gap between teenagers' perceptions and graduate students' experiences. In *Proceedings of the 3rd International Workshop on Computing Education Research (ICER'07)*.
- [20] K. Pantic, J. Clarke-Midura, F. Poole, J. Roller, and V. Allan. 2018. Drawing a computer scientist: Stereotypical representations or lack of awareness? *Comput. Sci. Educ.* 28, 3 (2018), 232–254. DOI: [10.1080/08993408.2018.1533780](https://doi.org/10.1080/08993408.2018.1533780)
- [21] Y. B. Kafai, E. Lee, K. Searle, D. Fields, E. Kaplan, and D. Lui. 2014. A crafts-oriented approach to computing in high school: Introducing computational concepts, practices, and perspectives with electronic textiles. *ACM Trans. Comput. Educ.* 14, 1 (2014). DOI: [http://dx.doi.org/10.1145/2576874](https://doi.org/10.1145/2576874)
- [22] C. Woratschek and T. Lenox. 2009. Student attitudes and perceptions regarding computing and its related disciplines. *Inf. Syst. Educ. J.*, 7, 58 (2009). Retrieved from <http://isedj.org/7/58/>.
- [23] E. M. Mercier, B. Barron, and K. M. O'Connor. 2006. Images of self and others as computer users: The role of gender and experience. *J. Comput. Assist. Learn.* 22 (2006), 335–348. DOI: <https://doi.org/10.1111/j.1365-2729.2006.00182.x>
- [24] C. M. Lewis, P. Bruno, J. Raygoza, and J. Wang. 2019. Alignment of goals and perceptions of computing predicts students' sense of belonging in computing. In *Proceedings of the International Computer Science Education Research Workshop*.
- [25] M. Guzdial. 2013. Exploring hypotheses about media computation. In *Proceedings of the 9th Annual International ACM Conference on International Computing Education Research*. 19–26.
- [26] B. Ericson, S. Engelman, T. McKlin, and J. Q. Taylor. 2014. Project rise up 4 CS: Increasing the number of black students who pass advanced placement CS A. In *Proceedings of the 45th ACM Technical Symposium on Computer Science Education*. 439–444.
- [27] B. Ericson and T. McKlin. 2018. Helping underrepresented students succeed in AP CSA and beyond. In *Proceedings of the 49th ACM Technical Symposium on Computer Science Education*. 356–361.
- [28] S. Stokes. 2021. A sense of belonging within the imaginative constraints of racial realism: A critical race analysis of latinx students' racialized experiences during the trump presidency. *Int. J. Qualitat. Stud. Educ.* (2021). DOI: [10.1080/09518398.2021.1956632](https://doi.org/10.1080/09518398.2021.1956632)
- [29] S. T. Jones and N. Melo. 2020. "Anti-blackness is no glitch": The need for critical conversations within computer science education. *XRDS Crossr: ACM Mag.Stud.* 27, 2 (Winter 2020), 42–46. DOI: <https://doi.org/10.1145/3433134>
- [30] M. S. Shaw. 2021. Restorying identity: Towards a development of critical identification with computing for minoritized youth. In *Proceedings of the Annual Meeting of the International Society of the Learning Sciences*.
- [31] M. S. Shaw, G. Ji, Y. Zhang, and Y. B. Kafai. 2021. Promoting socio-political identification with computer science: How high school youth restore their identities through electronic textile quilts. In *Proceedings of Research on Equity and Sustained Participation in Engineering, Computing, and Technology (RESPECT'21)*.
- [32] Joanna Weidler-Lewis, Wendy DuBow, and Alexis Kaminsky. 2017. Defining a discipline or shaping a community: Constraints on broadening participation in computing. In *Proceedings of the 2017 ACM SIGCSE Technical Symposium on Computer Science Education (SIGCSE'17)*. Association for Computing Machinery, New York, NY, 627–632. <https://doi.org/10.1145/3017680.3017776>
- [33] M. Perez. 2020. Understanding students' perceptions of computing through photo elicitation. In *Proceedings of the International Computing Education Research Conference 2020 (ICER'20)*.
- [34] M. Perez, P. Garcia, and B. Ericson. 2021. Former students' perspectives on the value of computing education programs. In *Proceedings of the Annual Meeting of the International Society of the Learning Sciences (ISLS'21)*.
- [35] K. Hatten, T. R. Forin, and R. Adams. 2013. A picture elicits a thousand meanings: Photo elicitation as a method for investigating cross-disciplinary identity development. In *Proceedings of the ASEE Annual Conference and Exposition*.
- [36] S. Fincher, J. Tenenberg, and A. Robins. 2011. Research design: Necessary bricolage. In *Proceedings of the 7th International Workshop on Computing Education Research (ICER'11)*. Association for Computing Machinery, New York, NY, 27–32. DOI: <https://doi-org.proxy.lib.umich.edu/10.1145/2016911.2016919>
- [37] S. Jordan, R. Adams, A. Pawley, and D. Radcliffe. 2009. Work in progress—The affordances of photo elicitation as a research and pedagogical method. In *39th IEEE Frontiers in Education Conference*.
- [38] A. Calabrese Barton, H. Kang, E. Tan, T. O'Neill, J. Bautista-Guerra, and C. Brecklin. 2013. Crafting a future in science: Tracing middle school girls' identity work over time and space. *Amer. Educ. Res. J.* 50, 1 (2013), 37–75. Retrieved from www.jstor.org/stable/23319707.

- [39] K. Charmaz. 2017. The power of constructivist grounded theory for critical inquiry. *Qualitat. Inqu.* 23, 1 (2017), 34–45. DOI : <https://doi.org/10.1177/1077800416657105>
- [40] J. Saldaña. 2009. *The Coding Manual for Qualitative Researchers*. Sage Publications, Inc.
- [41] L. Birt, S. Scott, D. Cavers, C. Campbell, and F. Walter. 2016. Member checking: A tool to enhance trustworthiness or merely a nod to validation? *Qualitat. Health Res.* 26, 13 (2016), 1802–1811. DOI : <https://doi.org/10.1177/1049732316654870>
- [42] P. Gerstenblatt. 2013. Collage portraits as a method of analysis in qualitative research. *Int. J. Qualitat. Meth.* (2013), 294–309. DOI : <https://doi.org/10.1177/160940691301200114>
- [43] T. Sengupta-Irving and S. Vossoughi. 2019. Not in their name: Re-interpreting discourses of STEM learning through the subjective experiences of minoritized girls. *Race Ethnic. Educ.* 22, 4 (2019), 479–501. DOI : [10.1080/13613324.2019.1592835](https://doi.org/10.1080/13613324.2019.1592835)
- [44] S. Vossoughi and S. Vakil. 2018. Toward what ends? A critical analysis of militarism, equity, and STEM education. In *Proceeding of the Education at War: The Fight for Students of Color in America's Public Schools*, Fordham University Press, 117–140.

Received 31 July 2021; revised 26 October 2022; accepted 18 November 2022