Need for Change: How Interview Preparation and the Hiring Process in Computing Can Be Made More Equitable

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Abstract

Media and literature frequently describe the need to increase the number of workers in computing to meet growing demands and highlight the necessity of broadening participation. Although companies may claim they want to do better, and some have begun to develop and implement initiatives to promote and improve diversity, ongoing reports of discrimination and metrics demonstrate there is still a long way to go to achieve inclusivity and parity in representation, particularly for women, Hispanic/Latinx, and Black/African American workers. To learn more about students' pathways to a career, especially those which are underrepresented in the discipline, and to examine what they believe may ameliorate interview preparation and the hiring process, we employed phenomenography. Phenomenography has been used in computing and engineering education as a qualitative methodology to assess how people may experience and conceptualize phenomena. This inquiry applied the theoretical framework of intersectionality to examine the experiences of minoritized undergraduate computing students and their pathways to job attainment, and to learn about what may help to improve the process. Specifically, the investigation was guided by the research question: *What do students feel would help to improve hiring in computing?* The participants included 16 students in computing, all of whom had completed at least one technical interview and received at least one job offer. The goal in phenomenographic data analysis is to develop an outcome space — the visual representation of a hierarchical set of distinct, but logically related, categories. From the analysis, an outcome space emerged with five main categories of description about the kinds of obstacles students encountered in regard to the hiring process in computing and industry practices: Uncertainty, interview techniques, time demands of preparation, anxiety management, and improving inclusivity. Yet, our goal was not to focus on the issues faced, but the solutions to resolve them. As such, the perceptions of the students' experiences guided the creation of a set of recommendations for students, academia, and industry, to mitigate concerns with the current process and to consider avenues for improvement.

1 Introduction

Over the next decade, computer and information technology occupations are projected to rise 11% [1]. However, disparities in the representation of women and racial/ethnic minorities are a known problem in computing fields [2–4]. While 21% of graduates in computer science (CS) are Black or Latinx, in the technology workforce they represent only 10% of the employees [5]. Intersectionality of gender, race, and ethnicity further compounds the issue. Women of color may comprise 39% of the population in the United States, but only 12% of women that are employed

in computer and information science jobs are Black or Latinx women [6]. Although technology companies may espouse they want to broaden participation, minimal progress has been achieved. Between 2014 and 2020, in total there has only been one percentage point of increase across major tech companies such as Apple, Facebook/Instagram, Google, and Microsoft [7]. Furthermore, unfair treatment remains an issue in the technology workforce, and has been shown to contribute to high employee turnover, particularly for underrepresented populations [8].

Careers in computing fields — referring to CS, computer engineering (CE), and information technology (IT) — can encompass a gamut of roles and companies. Despite the variations, obtaining any position requires undergoing the hiring process. While facets of hiring such as submitting an application or behavioral interviews may exist in other disciplines, hiring in computing often includes extra assumptions and barriers, such as the development of digital portfolios/websites and technical interviews that require advance preparation [9–11]. Technical interviews are a component of the hiring process that tests job candidates' computing knowledge, skills, and problem-solving ability [10, 12]. Using whiteboards, text editors, or pencil and paper, these examinations of technical acumen typically require live coding, while also encouraging candidates to speak through their thought process, and to find an optimal solution (in terms of algorithmic efficiency and memory allocation) [9, 10]. Prior work has shown that the convergence of these expectations, and the preparation they require, can be a major challenge for graduates looking to start their career. However, little is known about how students interpret the process, and particularly, the unique experiences of students minoritized in the field. As such, we sought to address this gap in understanding, and to find opportunities to improve student preparation and the hiring process.

This inquiry applied the theoretical framework of intersectionality to examine the experiences of minoritized undergraduate computing students and their pathways to job attainment, and to learn about what may ameliorate the process and preparation. Specifically, we sought to address the research question (RQ): *What do students feel would help to improve hiring in computing?* To obtain an answer, we employed a qualitative research methodology referred to as phenomenography.

In the rest of this document, we first describe what phenomenography is and review the literature pertinent to our inquiry in Section 2. Then, we discuss the theoretical framework that drove this research in Section 3. In Section 4, we detail the methods including the survey conducted, demographics of the population interviewed, analysis, and present the positionality of the first author. Then, we provide the results in Section 5 and a discussion of the findings in Section 6. In Section 7 we describe the limitations of our work, and we conclude in Section 8 with a summary and suggestions for future work in the field.

2 Related Research
We detail the methodology that guided this research in Section 2.1. Then we elaborate on background for the particular phenomenon we examined in Section 2.2.

2.1 What is Phenomenography?
Phenomenography aims to describe relationships between a specific phenomenon and participants' interpretations of their experiences [13, 14]. Understanding arises simultaneously from individual reflections, as well as through interpretation of the collective experiences across

groups of individuals to explore the similarities and differences. Data is often gathered using interviews, although there other other means for doing so, and then the transcripts from these interviews are examined [15]. Analysis occurs over several iterations, and involves assessing either the entire transcript [14] or decontextualized excerpts referred to as a "pool of meanings" [15, p. 43]. Both options serve to obtain the same purpose from the data, a conceptually distinct set of categories of description which encompass the different ways the phenomena is perceived. These categories have also been described as "expressions of understanding" [16, p. 210]. The desired end product of phenomenography is a visual or textual representation that encompasses these relationships amongst the categories, which is referred to as an outcome space [17].

2.2   The Phenomenon Under Investigation

Hiring in computing is typically a multi-step process that involves several stages of screening and interviews to examine job candidates' professional and technical abilities [10, 18, 19]. However, there is a lot of variability in what each individual interview may entail and how many interviewers may be involved (e.g., a single interviewer versus a panel) [10, 18]. As such, there is frequently a level of uncertainty for students going into hiring in general, but especially for technical assessments, in terms of what will be asked and what format to expect. Of the negative experiences students reported after a technical interview the most common concern is that students did not feel prepared [20].

Technical interviews are said to be a combination of "the worst aspects of a standard interview, public speaking, a quiz show with a hostile host, and a dinner party full of strangers who are silently (or not so silently) judging you" [11, p. 2]. Requiring candidates to find a solution, while verbally walking through the process, is often cognitively taxing, placing stress on candidates to perform in a setting akin to an examination [21, 22]. Additionally, technical interviews are criticized for potentially overlooking qualified candidates who may have the capability to succeed, but who struggle to perform in well high pressure situations [23].

In addition to real-time coding problems, often candidates are also tested on foundational knowledge in computing [10]. Such questions may include common data structures (e.g., stacks/queues, hashmaps, arrays), algorithms (e.g., graph traversals or recursion), or database principles (e.g., SQL queries, primary/foreign keys; [10, 24]). Answering these kinds of questions can be particularly challenging as they may require students to recall material they may not have seen since introductory classes in the field [25].

To succeed in the hiring process, and to perform well in these technical interviews and on computing questions, preparation is expected to begin months or years in advance [10, 26]. Platforms like Leetcode, GeeksForGeeks, HackerRank, or guidebooks such as Cracking the Code [10] are suggested to facilitate in depth understanding and to expedite speed in solving problems [12, 27]. However, many students do not prepare as far in advance as is recommended, and often White students and females begin preparing earlier and spend more time preparing than students that do not identify as White or as female [28]. Yet, such differences may be due to the inherent divide between those with more time to study and those unable to do so because of commitments related to family, health, coursework, or other jobs.

Apart from the inherent bias in the time expectations of preparation, in which inequities may exist in availability to practice [28], there are other concerns that may further limit participation of

underrepresented groups in computing. All students may struggle with knowing how to prepare for technical interviews, particularly since they may be unfamiliar with such problems, and fears of impostor syndrome may discourage them from going through the process. However, scholars have noted that for minoritized students, these concerns may be an even greater issue [29]. Such challenges are only further exacerbated by antagonistic or even hostile treatment from interviewers [30].

Additionally, when questions are created for technical interviews, they are often established by engineers with different backgrounds than those of the actual job applicants [30]. This is especially problematic when considering preferences in approaches and cultural differences that may further contribute to how each population best performs. For example, many design features of software are considered exclusionary for females, based on gender differences in motivations to use the software or in willingness to accept risks [31]. There are also differences in technical interview performance (time to solve and correctness) when the setting is public versus private [23]. Post-hoc analysis in this study illustrated that women's performance improved substantially when problem-solving in a private setting.

In this research, we sought to examine students' perceptions of technical interviews, and what would help to improve preparation and the hiring process in computing. Exploring the experiences of Asian, Hispanic/Latinx, Black/African American, and mixed race-men and women with the phenomena of job attainment and success in technical interviews can provide insights into approaches for broadening participation. This study is unique in its focus on underrepresented populations and in examining their experiences with the hiring process in computing.

3 Theoretical Framework

Intersectionality describes the mutually constitutive elements of identity, such as gender, race, ethnicity, sexuality, ability, etc., and how they overlap to impact individual experiences [32]. It calls attention to the systemic inequities that impact marginalized groups and describes the complexities inherent from straddling multiple axes of oppression [33]. For example, women of color may have distinctive experiences shaped by the "sum of racism and sexism" [34, p. 771]; see also [35]. In this research, we focused on students' gender, racial, and ethnic identities and explore the unique experiences and pathways job attainment in computing. This framework shaped the methodological choice, interview protocol, participant selection, and interpretation of the results.

4 Methods

All research was conducted after obtaining Institutional Review Board approval. We describe the participants further in Section 4.1. In Section 4.2, we describe the semi-structured interviews conducted to learn about students' experiences with the hiring process. The analysis is presented in Section 4.3 followed by the positionality in Section 4.4.

4.1 Participants in this Inquiry

The participants included sixteen undergraduate computing students. Participants were identified through a 46-question survey of CS, CE, and IT students from three metropolitan universities in the Southeastern United States ($n = 740$). The survey and questions asked have been previously

described in more detail in other publications [20, 28].

All the students selected from the survey reported having completed at least one technical interview, and among those which had, all received at least one job offer. To learn about the unique pathways to a career for minoritized populations, and what may encourage them to succeed, we sought to obtain roughly equal numbers of students that identified as men and women belonging to different minoritized racial or ethnic groups. All participants that met this criteria, based on their survey responses, were contacted via email to voluntarily participate in the interviews. The details of the participants are described further in Table 1. It should be noted that all pseudonyms were chosen by the participants.

Pseudonym	Major	Gender	Race and/or Ethnicity
Alessia	CS	Female	Asian
Tulip	CS	Female	Asian
Deanna	IT	Female	Black or African American
Julia	CS	Female	Black or African American
Taylor	IT	Female	Black or African American
Leia	CS	Female	Hispanic/Latinx
Maria	CS	Female	Hispanic/Latinx
Eliza	CS	Female	Hispanic/Latinx, White
Ravi	CS	Male	Asian
Steve	IT	Male	Asian, White
Michael	IT	Male	Asian, Black or African American, and Hispanic/Latinx
Jordan Henry	CS	Male	Black or African American
Kevin	CE	Male	Black or African American
Alex	CS	Male	Hispanic/ Latinx
Frank	CS	Male	Hispanic/Latinx
Ramon	CS	Male	Hispanic/Latinx

Note: CS= Computer Science; CE= Computer Engineering; IT= Information Technology

Table 1: Participant Information

4.2 Data Collection
We applied semi-structured interviews to learn about students' experiences with technical interviews, and to explore what could improve their preparation and the hiring process in computing. Intersectionality guided the creation of the interview protocol. However, it should be emphasized that the questions established were not intended to consider the participants as merely an amalgamation of distinct social identities, but instead to offer a "set of dynamic and unpredictable productions that have shaped subjects' life experiences and opportunities" [36, p. 144].

The protocol was evaluated using pilot interviews to ensure clarity in the questions, to verify that the questions asked actually elicited responses on the topics of interest, and to allow the interviewer to hone her technique [37, 38]. In total, three individuals were interviewed as part of the pilot, using students identified through convenience sampling that stated they had already completed technical interviews. Yet, the transcripts from these pilot interviews were not included in the analysis presented in this paper. Instead, another sixteen participants (see Table 1) were recruited and interviewed. The interviews were conducted remotely via Zoom during the Fall semester of 2020 using the amended protocol. The interviews ranged between 21 and 92 minutes.
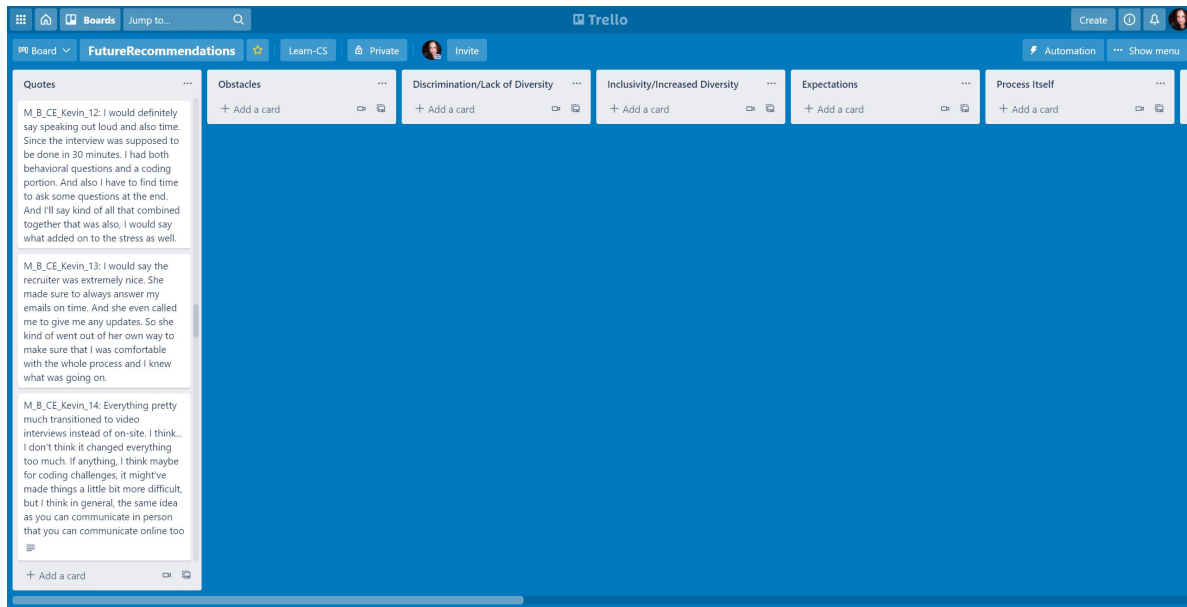
Figure 1: Example of Trello board to organize pool of meanings

There was variability in length of interviews (as often is [38]); however, all of the participants answered all of the questions; some were more verbose than others.

4.3 Data Analysis

Data analysis began after all the interviews were completed. Given that team analysis can enhance reliability and validity [37] — critically assessing, critiquing, and offering diverse perspectives — additional researchers were included throughout the process. Experts in qualitative research, and phenomenography specifically, were consulted when planning the experiment and when designing the interview protocol. During the analysis phase, additional researchers were involved as described further below.

All audio recordings of the interviews were transcribed and confirmed by another researcher. Then, the first author read each transcript as a whole over multiple iterations. Direct quotes relevant to the RQ were identified, highlighted, and tentative themes were interpreted and extracted over each round. Next, an independent researcher reviewed a transcript rich in theme diversity to confirm existent labels and to suggest additional ones that may be relevant.

We employed the pool of meanings approach [15] for the subsequent analysis. This choice was made since students often had multiple hiring experiences which varied by encounter, and they typically described pertinent details of each throughout the interview. Once a list of quotes were chosen and initial themes were established, the pool of individual excerpts from the transcripts were stored to a Trello board (see Figure 1). As shown, each tentative theme was used as a column header for assignment.

The next step in phenomenography involves organizing the results based on similarities and differences in meaning. Towards this goal, two researchers (the fist and second authors), using separate boards, then independently assigned each quote to one of the columns. Upon

completion, they met to review and negotiate on the labels assigned and on the definition of the theme. The final outcome space was also derived from several rounds of iteration. It is presented visually as the structural representation of the relationships that emerged between the categories and across the themes.

4.4 Positionality

Since categories of description in phenomenography are sensitive to lived experiences, researchers have expressed the necessity of presenting the researcher's position which may influence communication and interpretation of the analysis [37, 39, 40]. Along these lines, we acknowledge that the first author did conduct the interviewers and lead the analysis. Accordingly, we want to share the position of this author and her experience with the phenomenon explored since it can impact the interactions and presentation of the perspectives observed.

The first author is a White, non-Hispanic or Latinx, female student in computer science. While she has faced sexism, she has not dealt with racism directed towards her. She previously has undergone the hiring process in computing, and has encountered technical interviews. Her familiarity with the topic, along with the literature in the field, shaped the development of the interview questions. Her prior experiences also helped to build connections with the participants during the interviews.

5 Results

The students we spoke with reported a range of hiring experiences for an assortment of positions. Many students had interviews with multiple companies. Within the process of interviewing for a single company, there were often several rounds of job interviews, each with varying numbers of interviewers and distinct challenges. In the results that follow, we describe the broader aspects of hiring in computing and what students feel would improve the process, as interpreted through the collective perceptions identified in the pool of meanings, rather than individual instances of the interview process. In addition to the variation in participants' exposure to different interviewing expectations and procedures, our intersectional representation of participants provides insight into the variation of perceptions of these processes, resulting in a rich, inclusive outcome space.

We first present the outcome space in Section 5.1, which uses a figure to visualize the relationship between the five categories of obstacles encountered during hiring. In Section 5.2, we delve into more detail on each category of description that emerged. Finally, we break down each of the themes that offer recommendations to overcome these barriers in Section 5.3. Direct quotes are given to provide detail and illustrate each potential option for improvement.

5.1 Outcome Space

The outcome space is illustrated in Figure 2. The categories of description surrounding the obstacles encountered are depicted in relation to the particular agent for change (academia, industry, or students). The relationship between the themes and the categories are also presented. For example, under the heading of academia, creating a course for students to help prepare them for technical interviews would not only serve to help reduce anxiety by familiarizing them with the style of questioning they could later encounter, but it could also help with the time demands of preparation. Given that students may have different commitments, and may be caring for family or working other jobs (as described in [28] and by students in our interviews), offering a course

within the curricula would ensure all students are aware of the expectations ahead, and could give them the opportunity to practice without the burden of trying to find additional time outside of that already allocated for coursework.
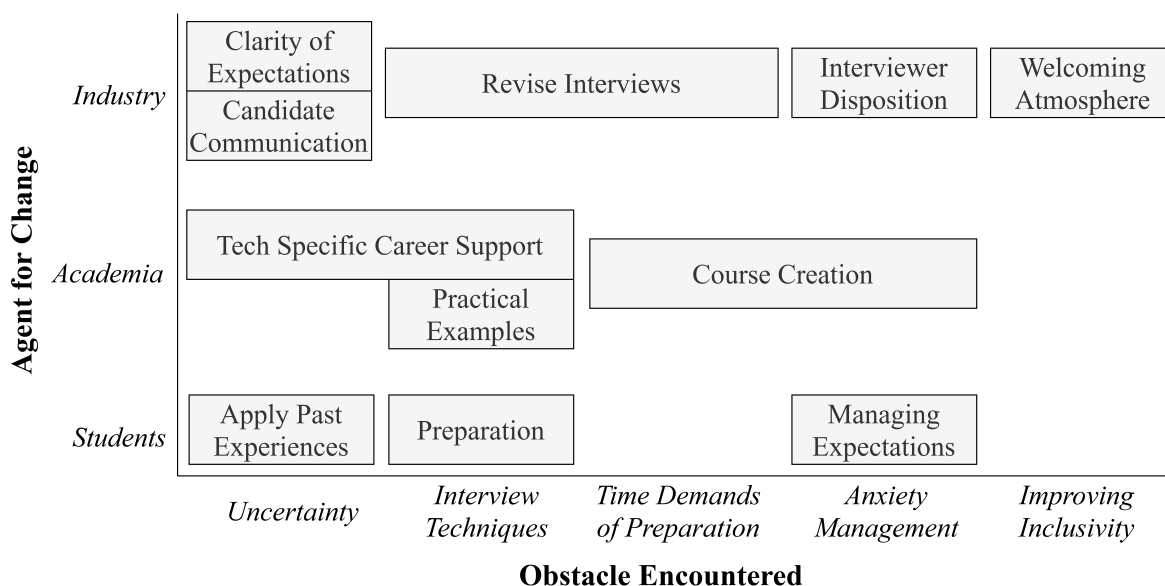

Figure 2: The outcome space describing ways to overcome different obstacles encountered

5.2   Categories of Description, Obstacles Encountered
Here we continue the description of the outcome space by providing further detail about each of five main categories of description (Table 2). Specifically, these categories correspond to the kinds of obstacles students encountered: Uncertainty, Interview Techniques, Time Demands of Preparation, Anxiety Management, and Improving Inclusivity. In this table, examples are provided that highlight the broader issues noted.

5.3   Themes Surrounding Recommendations to Improve Student Preparation and Hiring
From the responses within the pool of meanings, 11 themes emerged surrounding potential ways to improve student preparation and the hiring process in computing. Each of these themes fell along the axis of three agents for change — Industry, Academia, and Students. The complete list of themes for each is:

- *Industry*: Clarity of Expectations, Candidate Communication, Interviewer Disposition, Welcoming Atmosphere, Revise Interviews

- *Academia*: Tech Specific Career Support, Practical Example, Course Creation

- *Students*: Managing Expectations, Apply Past Experiences, Preparation

5.3.1   Industry: Clarity of Expectations

Students often mentioned a disconnect between what they expected and what they encountered in the interviews. Deanna (a Black female) said "I would say I wish they gave kind of a little bit

Category	Description	Example
Uncertainty	The ways the student felt unprepared, unsure of what to expect in the hiring process, or where they stood in relation to their performance on the interviews.	Ravi: I think [the] biggest challenge for me was I just was at a position where I didn't know that much about the field of computer science. So it was hard for me to feel confident in what I was saying, or feel like I had the skills necessary to get the position.
Interview Techniques	The need to acquire technical or behavioral skills in order to navigate through interviews.	Tulip: In the technical department, my biggest challenge was definitely trying to go back to the things that I had learned about maybe half a year, a year ago. The topics that they were asking me, they didn't give me anything to prepare. And it had been a while since I first learned it. And I don't generally use those things in my projects today.
Time Demands of Preparation	The issues that limited preparation ability, such as commitments to family, friends, courses, or other jobs.	Ramon: I don't have a lot of free time because I have a family. I was also working full-time while going to [school name], and while doing interviews. So I didn't prepare that much.
Anxiety Management	Factors that could impact performance in the interviews, and that are sources of stress during hiring.	Julia: Lowering my anxiety was the biggest challenge, because again, I was intimidated the first time because I didn't really feel like I had enough interaction with real founders and recruiters to really...Yeah, that was really it. I was just really intimidated by them.
Improving Inclusivity	Feelings of isolation, discrimination, and reduced diversity, and need for the hiring process, universities, and industry to be more inclusive.	Steve: I still feel that there's like a stigma being a woman working in a tech industry. You may get harassed. You may get called things. You may have other people predisposed to kind of how women "Women can't do whatever, why don't you just go Google something." Something like that. Something almost, almost...like a parody of itself. Except that I know that it happens because I have friends that are women in the tech field, and these very Onion-esque article headline things happen to them in real life.

Table 2: Categories of obstacles encountered with the current hiring process in computing

more clarification just because the interview I had and the interview I was expecting were completely different."

They mentioned that industry could improve by giving more information and resources upfront to know what to expect, and how to prepare. As Tulip (an Asian female) commented "with the first few that didn't give me resources. With the next ones I have that are giving me resources, it makes me feel a lot more confident and prepared."

5.3.2 Industry: Candidate Communication

Many participants commented they wanted more communication from companies, and prompt and timely responses about their status. Often, they stated they did not ever receive a formal rejection. As Leia (a Hispanic female) noted:

> When I first started applying, I started applying back in August, and I didn't hear back for a while from some companies. Now that I'm already ready to sign an offer, I'm hearing back from companies and I'm like, well, but I applied two months ago. I don't want to interview now, and I already have an offer. I know they get a million applications, too. Some companies just get too many applications, but maybe they can just reply faster to applicants and let them know the decision maybe. Not like two months after.

Contrarily, students felt there was huge merit to providing updates, and cited the benefits when they do hear back, such as Frank (a Hispanic male):

> They were very communicative, as I said completely amazing experience, because even though they didn't really need to send a follow up email like explaining why, they just mentioned 'We still think you're a little bit young, but we really loved what we saw, there was only good things said about you from our people.' It was very encouraging. So that really helps in general, even though it was not an offer. You don't consider that a failure because it really builds you in a way. It really helps you to still feel confident about your capabilities.

5.3.3 Industry: Interviewer Disposition

The way that the interviewer and recruiter acted often played a big role in students' impression of the interview and company. Not only could it deter them from proceeding with accepting an offer, but it could also impact performance on technical components as described by Maria (a Hispanic female):

> I'm wondering when they don't seem that friendly. It's definitely very discouraging during the interview to...I don't know, that constantly deter off my confidence and stuff, so that's not good. They shouldn't be acting like that. And it's probably not me. It's just, I don't know.

Even within the interviews at the same company, students reported there was often a "good cop/bad cop" dynamic, and that they were more likely to be successful when they felt the

interviewer was attentive and positive. Michael (an Asian, Black, Hispanic male) described his experience interviewing at a large technology company:

> So, the technical interviews, there's two of them. So, it was kind of I feel like a mix of reasons on why the first interview was kind of rough, primarily because I just completely froze and I was nervous. It was my first big boy interview. But I can tell that the interviewer was kind of annoyed with me because I was struggling and I could hear him on his phone texting. And I would ask him a question and he would just be like, 'Ah.' So, that kind of sucked. The second interviewer though was very responsive, very attentive. And I did perform better. Unfortunately, I didn't get the job. But that's beside the point. But yeah, so the first interview was kind of rough, just from both ends, me and the interviewer. But the second one was a lot friendlier.

He continued on to say:

> The second interviewer, I can't say the same for him. He was way more responsive, walking me through the problem when I had questions. And I think having someone there who it doesn't feel like they've already given up on you, I think that definitely affects performance.

5.3.4   Industry: Welcoming Atmosphere

Creating a welcoming atmosphere was important to students not only during the hiring process, but also in the workplace. Many students reported that their interviewers were White or Asian males. Although students did occasionally see women, Hispanics/Latinxs or Blacks/African Americans, they were more likely to be recruiters, particularly at career fairs centered at targeting diverse populations (e.g., those hosted by the Society of Hispanic Professional Engineers, SHPE), than to serve in technical roles. Julia (a Black female) commented "I guess one thing that kind of bothered me a little bit is the fact that I haven't had an interview yet with another woman who's in my field. All of them have been guys."

Several of the females also noted being the only one in their department, and that they may have been talked down to, or given different tasks than their peers. While they did not often directly label the sexism or racism they encountered, they also did not always feel that the field was inclusive. Many were uncertain what could be done to improve the situation, however, students such as Deanna (a Black female) suggested companies take the time to ask:

> I think it would, what's one thing that could be really insightful is just...the very few that are in computing that are from diverse groups, I think if communication was with them a lot, if there was more communication with them in terms of, like what you're doing right now, asking me 'What do you think could help with increasing the diversity in computing?' I think companies or any of the disciplines can do the same thing. They could just reach out to their employees that are from these diverse communities and ask them, ask them the question that you're asking and ask them to help with increasing the amount of people in, and also like giving their support towards it. I think. And I also think the responsibility of bringing in more diverse individuals shouldn't fall on individuals that are already diverse. It should be a

concern for everyone in the company. I don't think Black people should just bring in Black people. I don't think women should just bring in women. I think it should be a concern for every discipline...for every person there. So if you don't identify with either of those groups, it should still be your concern and it should still be something you're striving to do.

5.3.5 Industry: Revise Interviews

Overwhelmingly, students noted that the hiring process in computing was distinct from other fields, and that it was not always a great reflection of their skills or performance. They often preferred more of a focus on behavioral assessments, particularly when interviews felt like organic conversations, or even take-home assignments. They spoke about how when coding in technical interviews, such settings were unrealistic, because even on the job they could always search online for solutions when they got stuck. As Alex (a Hispanic male) commented:

I'd say that the main thing that I wish was a little different is that they maybe moved away from those type of questions where it's like write me a function that does this, or write me code, write me code, because a lot of the times when you're going through a problem, whether it be in the workforce or just in general, you have a lot of resources that are available. In my experience, when I've been on internships, my managers have never had a problem with me looking up something or using code that I found online. Obviously they don't want me copying and pasting the whole thing, but that's something that I guess I have kind of seen a tradition.

In addition, they spoke to the immense preparation required, as with Jordan Henry (a Black male) who said "I wish there was no coding challenges. I understand that it's a very vital aspect, but at the same time it feels like there's a need for preparation beforehand. And it doesn't really showcase your actual skills."

5.3.6 Academia: Tech Specific Career Support

While many students mentioned their campus did have a career services department, they also expressed they would prefer more technology-specific career support. They mentioned that many times the support and awareness of what to expect comes from organizations and clubs on campus, so even raising awareness of those opportunities for students early in their careers could be beneficial. In addition, they requested mock interviews or practice with speaking to develop communication skills, and also requested that departments consider more hands-on and practical examples. Ramon (a Hispanic male) commented that theory was well covered, which was something several students expressed, but that:

The actual practice, the hands-on, it was not covered that much. So to put an analogy, for example if someone who goes to a bootcamp is more prepared on that part that [university name] lacked of teaching. Because for example...It's a challenge, I understand the university. It is not there to do that. You know, the professor are not up to date with the latest technology. They doesn't work in the industry. So that is a gap there that the bigger university doesn't cover, that you have to learn about yourself.

And when you go to the market, you'll see that it is like, Wow, there is a lot that I need to learn, that I didn't learn in the school.

5.3.7 Academia: Practical Examples

Students frequently mentioned they would like practical examples and more hands-on training in their coursework. They mentioned they found a lot of what was covered in class to be fairly simple relative to what they encountered later, and as such, would appreciate being challenged. Jordan Henry (a Black male) stated "I would say more practical usage of programming, like web development or, what is it? Mobile development, website development. Just more applications of programming rather than just the topics themselves."

In addition, Michael (an Asian, Black, and Hispanic male) noted:

> I think just making it way more hands-on and a little bit more updated I think would have been better. The coding classes, a lot of the coding classes I took, only a few of them really challenged you. A lot of them kind of, professors gave you pretty much the solutions and didn't really challenge you much.

5.3.8 Academia: Course Creation

Many students encouraged universities to create an elective or core class to help students prepare for the hiring process, and develop their technical and professional skills. Such a course could include practicing interviews, learning how to approach programming problems step by step, and solving questions as needed for technical interviews (e.g., quickly and on a whiteboard). They noted how they often had outside commitments that interfered with their ability to prepare more, such as caring for family members, or even studying for exams in classes. As described by Leia (a Hispanic female):

> I know school wouldn't do interview prep, like in terms of, I guess, coding questions, but maybe...Actually, that could be a class, problem solving, kind of. Cause I know, I think Programming III...It really depends also on the professor you take as well. I don't know. I'm not sure. I guess maybe problem solving, tips and tricks of how to do a problem, because sometimes, you might want to do extra work in terms of...But you might want to sit down and do Leetcode but you're already so tired from the work that you're doing for five classes that you're taking that you don't have the energy to sit down and do Leetcode. Maybe one of those classes could be just interview prep on problem solving.

Ravi (an Asian male) felt similarly:

> Mock interviews definitely, how to prepare, how to interview, how to apply basically, how to network, stuff like that. So all those... or quick meetings that they have after class, except go how to network or how to do technical interviews. If you put all those into one class, I think that could be super [inaudible 00:21:06] and students are required to take it. Because if you have these meetings and people don't have time or people have jobs, it's hard to do on top of classes, so if you had your own three, four credit class, that would be super beneficial definitely.

Other students mentioned how they felt uncomfortable speaking, or how they noticed others in the department struggled with communication. As such, they felt gaining practice could help to better prepare, as emphasized by Michael (an Asian, Black, and Hispanic male):

> I think providing students with some sort of soft skills interviewing course or something, that's definitely neglected in both or just the engineering department. I think giving students that knowledge and really pushing them out of their comfort zones would help everyone tremendously. Like I said, for a lot of those students are really headphones on coding away, which is great. There's a lot of smart kids in that degree. But it takes more than just being able to code to have a successful career. So, I think, man, even just giving speeches or something, being able to do public speaking more or a mock interview course, maybe you do like, what, five interviews in the semester or something, I think that would be a great experience.

At one point Stanford did offer such a course [41], and students interviewed also pointed to a competitive programming class they had heard about from friends at another university which helped their students gain experience with questions similar to those encountered during technical interviews. However, such opportunities were absent in the schools examined, and are more likely to be the exception rather than the norm for students.

5.3.9 Students: Managing Expectations

Students frequently observed a lot of variability in what they encountered relative to what they had expected. They noted differences between larger and smaller companies, and cautioned students against going in with preconceived notions. As Steve (an Asian and White male) commented:

> I suppose to go in with a very open mind on what they can be, and what they may end up being. I mean, it could be anything from not having a tailored suit could cost you the job, or you go in wearing the same clothes that you've worn in high school and you will be completely fine. I mean there's just so much difference in what it could be, and what I've had friends experience versus what I've experienced. I mean it is a complete just…open…just an open book of what it could be.

Also, they suggested applying to as many jobs as possible since each was so distinct, and it could be a lengthy process to even get an interview. Ravi (an Asian male) stated that students should "Not to get super stoked about an interview or get your hopes up, or put all your eggs in one basket for one interview."

5.3.10 Students: Apply Past Experiences

The participants also mentioned that it was important to apply past experience or knowledge to solve problems during the interviews. They suggested that students should state any assumptions made. Additionally, they described how framing responses based on what was known could trigger ideas relevant to answering the task at hand. Frank (a Hispanic male) commented:

> So with the first [interviewer], as I mentioned, I was able to talk to him, and it would really just promote me going back in my head to any practice or anything that I had

learned that would help me with this.

5.3.11 Students: Preparation

Students regularly commented on the importance of preparing for interviews in advance. Frank (a Hispanic male) noted:

> I think that in general, the preparation is an amazing tool that we have, and it could be definitely exploited better. To help issues as imposter syndrome be overcome, in a healthy way, rather than I guess...I'm sorry. I would just finish off by overcoming confidence issues in a healthy way.

Also, it was considered important to spend as much time as possible preparing, as indicated by Kevin (a Black male) who said, "You have to prepare sometimes months in advance and not just maybe a few days or weeks in advance."

Students mentioned doing mock interviews with friends, online resources, and preparatory books, such as those suggested by Julia (a Black female):

> I think with technical interviews, it's very important for you to check your resources. If you ever have free time, it's always best to try and do some practice problems with Leetcode, HackerRank. Or you can...there's this really good book for prepping called Cracking the Coding Interview. It's a really good book for programmers. Those are really what I'd encourage people to use if they're trying to prepare for a technical interview.

6 Discussion

Evident in this work is the ongoing concern that although universities and industry are trying to broaden participation, there is still a long way to go to resolve current inequities. Corporate efforts to increase recruitment of minoritized students from venues such as the Grace Hopper Celebration of Women in Computing or the National Society of Black Engineers (NSBE) conferences may improve diversity in the applications received, however, to increase persistence and retention, it may be important to cultivate more inclusive thinking in the field, and to reform hiring and workplace practices that may continue to deter applicants. In the sections that follow, I provide specific recommendations for industry, academia, and for students.

6.1 Industry

Apart from the moral, financial, and innovation value of building diverse teams in a workplace, considering the intersectionality of individuals can play a critical role in leveraging the assets of men and women that self-identify as a racial and/or ethnic minority [42–44]. Employers should appraise the opportunities to harness the unique capital that different people can contribute. For example, a multi-lingual employee may possess better developed skills to interact or negotiate with clients, since they may have served as interpreters that translated phrases or culture to their own parents or relatives [45–47].

Industry must also assess its role in perpetuating inequities and how they can create a more welcoming atmosphere. Of note in our interviews, men infrequently reported experiencing blatant discrimination or feeling "alone" as often as the women did. However, the men we interviewed

were often aware of the sexism faced by their colleagues and friends, and frequently pointed to specific examples and instances. These reports highlight the ongoing concerns and compounded issues women of color face.

To truly make hiring and the workplace more inclusive, change is required at multiple levels [30, 48]. In the context of technical interviews, a first step is diversifying the engineers or managers that are present and asking questions. This shift may encourage intersectional confidence, as men and women of diverse backgrounds see others like them. This can also be valuable in the workplace post-hiring as well. In alignment with what Asian, Black/African American, and Hispanic/Latinx women reported in our interviews, prior literature has also described how Black women often feel isolated and recognize a lack of representation of others like them in computing [49]. To combat these issues, "Organizational supports to develop their leadership were seen as extremely efficient because these women would immediately give back, supporting other Black women in computing community (and other marginalized groups in computing), sharing experiences and mentoring staff" [49, p. 227].

Although English may be required on the job, and candidates may be able to speak and understand it, students reported that having to interpret an interviewers' accent could pose a problem in understanding questions asked during interviews. As such, trying to decipher what was being requested, on top of dealing with an already stressful technical interview challenge, can be especially difficult. Decoding while listening is described not only in terms different speakers with their own accents, but also how the same speaker may say particular words uniquely as part of sentences or in isolation [50]. Paran has mentioned, that listeners at all levels may struggle to recognize words, and that there are fewer forms in written words. As such, a simple solution in regards to technical interviews, may be for all employers to write down the question or prompts for all job candidates, so that they can reflect on finding a solution, rather than needing to decipher what is being said.

Furthermore, even before hiring begins, companies should be transparent in what candidates can expect. Being upfront about how many stages their process will entail, how long it may take to hear back, and what kind of technical components will be expected can ensure that all applicants start on equal footing. Similarly, offering study guides that restrict the topics candidates may encounter or need to review, could reduce some of the burden for students that have limited availability to study based on other commitments.

Long term, industry should consider refining or replacing the current hiring process altogether. Although it may be important to ensure all candidates possess the technical and professional skills needed for a position, current practices may not be the best method. To be mindful of how much preparation is needed, companies should instead think about offering more take home assignments, or providing applicants the opportunity to talk through their solution to problems recently encountered at the company. In tandem, they could offer training during onboarding for all employees, which could serve to provide the added benefit of all recent hires being familiar with their stylistic, algorithmic, and system design preferences.

6.2 Academia

Universities should consider embedding inclusive behaviors and mentalities early on in students, teaching them to embrace diversity, and the importance of giving all students the chance to take

on leadership roles and to gain practice with different tasks. As a small start, group projects, particularly in software engineering courses, could encourage revolving roles that allow each team member to gain experience working on different components, with differing levels of responsibility. This requirement could ameliorate concerns mentioned by females that they are often relegated to secretarial roles or tasks that may be less critical to outcomes. It also aligns with prior literature that encouraging leadership development can be beneficial for Black women, and can also help to develop skills "in preparation for the workplace" [49, p. 227].

Students also suggested they would prefer supplementary practical examples. Given that many concepts are abstract, and can be challenging, offering increased applications may help with knowledge transfer and understanding [51]. Prior studies have demonstrated how making computing content accessible, and relating CS to everyday life can be a valuable pedagogical approach [52]. Moreover, providing students with more opportunities to gain experience through projects, which can also serve to develop their problem solving and digital portfolios, is something that could be incorporated into coursework. While students did not mention completing individual oral examinations, including them within the curricula could also serve to help students prepare for the expectations of future interviews.

Alternatively, rather than just embedding preparation into existing coursework, administrators and faculty could consider the creation of a class focused on technical interview preparation. Such a course is something that students frequently mentioned would be beneficial. Particularly for students that work, or that have other outside commitments, creation of a designated course could alleviate some of the burden and stress, and would help to level the playing field to ensure more equitable preparation [28]. Giving opportunities to solve challenging problems on a whiteboard, teaching interview skills, and offering students opportunities to practice with mock interviews could improve communication and could enable them to test out different strategies in a low pressure environment. Previously, Dillon et al. ([53]) integrated virtual whiteboard problem-solving exercises into CS classrooms at a HBCU and found it "garnered favorable psychosocial behaviors from the students even though many of them lacked prior experiences with the coding interview style of problem solving." As such, it reinforces the potential benefits of including such material even if students may be unfamiliar with that style of approaching problems otherwise.

Furthermore, integrating a practical course as part of the Bachelor of Information and Communications Technology (BICT) degree at a university in New Zealand yielded additional positive insights [54]. The course itself offered students information about what to expect from the interview process, typical formats and questions, and other tips on presentations and non-verbal communication. Then, the course included a role play session, simulating technical interviews. Although initially the students reported feeling anxious before the interview role play, as the sessions wore on the students noted they began to apply the lessons learned from the preparatory process and to feel more confident in their answers. As weeks passed after the fact, and the students reflected on the simulation experience, they noted how beneficial it had been. Although this is not a component typically offered with computing degrees around the world, it provides a useful model to what such a course, or addendum to a capstone project, could look like.

While changes to the curricula may take time, in the short term, universities should consider

offering tech specific career support. Furthermore, departments should also inform students early on in their academic careers what hiring entails in the field, and they could provide information about resources that can be used to study for technical interviews. Finally, we suggest they make students aware of the value of internships, and describe which professional organizations are available, and the benefits of community development and preparation.

6.3 Students

The focus on the paper is to identify opportunities for changes to the structures rather than the individual. However, industry and academia are not the only ones who can enact change, and students can play an active role in developing their knowledge and preparing for the interview process as well. As other scholars have described [12, 27, 55], online coding resources such as Leetcode, GeeksForGeeks, and HackerRank can be assets to improve problem solving ability and speed. In addition, books such as Cracking the Coding Interview [10], can provide further opportunities for technical understanding and growth. Moreover, it can be useful to lean on social support throughout the hiring process. Family and friends have a positive impact on students' computing identity, a construct intertwined with their engagement and development in the discipline [20].

Clubs and organizations can also serve as valuable resources to prepare for a career and can help underrepresented students to find a community [56]. Multiple students in our interviews mentioned how groups, such as NSBE, offered interview preparation and/or networking opportunities that were beneficial for their professional development. They also described how workshops and sessions organized by the groups taught them what to expect from the hiring process in computing. Likewise, undergoing mock interviews can further help students to gain practice and build their confidence.

Students should be cognizant that it can take time to find a job, and they should try to manage their expectations. However, they have the tools to succeed, and are capable. Participants that had already attained a position in this study emphasized that it was helpful to apply past experiences when solving problems during interviews. As challenging as it can be, speaking through each thought while solving, and describing the preferred approach can help to find a solution or to recognize errors. It is also acceptable to ask questions to interviewers, and it is critical to ask for clarification when necessary. While the hiring process may be discouraging, preparation and perseverance can be valuable for obtaining a computing position.

7 Limitations

The findings from this investigation are limited in several ways. First, as observed in the variation of the time length of each of the interviews, there may have been differences in how much detail each respondent gave. This is a potential area for future analysis to investigate how this may have introduced differences in the responses. In addition, experiences are limited to participants' recollections, and they may not recall salient details from interviews or feel comfortable expressing them. As described by Brown and Kulik (1977), emotionally significant events are more often recalled vividly than banal experiences [57]. Accordingly, the more mundane encounters and interactions during hiring many have been forgotten relative to the extreme positive and negative experiences. However, as Åkerlind has previously pointed out, "a phenomenographic researcher asks not how well their research outcomes correspond to the

phenomenon as it exists in 'reality', but how well they correspond to human experience of the phenomenon" [17, p. 330].

We also want to acknowledge the potential influence of the COVID-19 pandemic, which may have impacted students' experiences and perceptions of the hiring process. Although the students shared their various hiring experiences over longer time spans, the pandemic did often result in on-site interviews transitioning online. Although we did ask how COVID-19 may have affected their studying and hiring processes, it was not the focus of the study. Going forward, researchers may want to explore the changes more explicitly.

Furthermore, this data is reflective of only a subset of job seeker experiences, and may differ between students or companies. As such, these results cannot necessarily be generalized to all computing students, nor to all minoritized computing students.The responses demonstrate experience variability in the hiring process and in discrimination issues encountered, and supports the tenants of intersectionality in the uniqueness of the experiences of Asian women, Hispanic/Latinx women, and Black/African women.

8   Conclusions

Evident in this work is the ongoing concern that although universities and industry are trying to broaden participation, there is still a long way to go to resolve current inequities. Corporate efforts to increase recruitment of minoritized students from venues such as the SHPE or NSBE conferences may improve diversity in the applications received. However, to increase persistence and retention, it may be important to cultivate more inclusive thinking in the field, and to reform hiring and workplace practices that may continue to deter applicants.

Largely the burden falls on industry to revise technical interviews and to create a more welcoming atmosphere. Nevertheless, until such changes occur, institutions and students need to be ready to tackle current systems. Universities should make students aware of the expectations required to obtain a job early on in students' careers and should also promote organizations that may serve to help students find their own community. While some suggestions are a bit easier to implement (e.g., educators giving more practical examples), and others that may take considerable time and effort (e.g., creating courses to aid in preparation), universities should consider the value these could offer. Not only could these recommendations aid in students' preparation for a career, but they could also help them to apply and practice more theoretical concepts taught in classes. Yet, students must also do their part, and they should be sure to study and gain familiarity with the topics they are taught. While it may be a challenge to overcome imposter phenomenon, they can succeed.

Knowing that the hiring process in computing is flawed is insufficient. Instead, it is important to consider what the issues are, to find ways to fix them, and to make the process more equitable for all. Going forward, we must work not just to broaden participation within universities and in industry, but also to develop inclusive environments, policies, and mindsets.

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