Characterizing Women's Alternative Pathways to a Computing Career Using Content Analysis

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ABSTRACT

Technology innovation requires a set of diverse employees with computing skills. Yet, it remains a challenge for the global digital labor market to obtain an equitable representation of women. This is particularly true for women who enter the computing workforce after obtaining an initial undergraduate degree in a non-computing field. To resolve discrepancies, it is important to learn more about the factors influencing career trajectories and the possible alternative pathways that may encourage participation in the field. We define alternative pathways as any post-baccalaureate program or training that meets the needs of bachelor's degree-holding women with computing aspirations. This research paper, guided by Schlossberg's Transition Theory, conducted a content analysis on publicly available job profiles to characterize the types and features of alternative pathways commonly chosen by women in the United States (U.S.) to aid in understanding their transitions into a computing career. Findings from this study provide guidance and suggestions to women who are interested in transitioning to computing later in their career paths. It further outlines potential avenues with actionable recommendations for the computing education community to attract and retain women in the computing workforce in an effort to build an inclusive ecosystem.

CCS CONCEPTS

• **Social and professional topics → Computing education**.

KEYWORDS

Women in Computing, Broadening Participation, Alternative Pathways, Computing Careers, Computing Education

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1 INTRODUCTION

Computing is one of the key industries driving the digital revolution that will shape the future workforce [32]. Between 2021 and 2031, computer and information technology occupations in the United States (U.S.) are projected to have a growth rate of 15% [22]. This expansion requires diverse employees with computing skills and different approaches to tackling global problems. While it has been well established that encouraging women's participation and retention in computing is critical, they remain underrepresented in the field [32]. Even more concerning, it is estimated that women account for 70% of the jobs with a high risk of automation, increasing the likelihood of their unemployment [33]. As such, it is beneficial to learn more about the factors that may impact women's career decisions and to find opportunities to encourage the participation and retention of additional women in computing.

Although studies have shown engagement with computing fields encourages students' career aspirations towards a computing occupation [12], less is known about the influences which may impact women's career trajectories. In particular, there is a lack of understanding about those who currently work in the industry but do so through an alternative pathway. For the purposes of this work, we define ***alternative pathway*** as any post-baccalaureate program or training which meets the needs of those with computing aspirations for individuals without an initial undergraduate degree in the field. In our research, we focus on women, particularly those who did not obtain their first bachelor's degree in computing. Exploring the backgrounds of these women who enter the field through alternative pathways furthers our understanding of potential avenues to attract and retain an untapped talent pool. This research serves as a pilot study in which we sought to characterize the types and features of alternative pathways commonly chosen by women in the U.S. The research questions (RQs) that drove this study were:

- What are some of the career trajectories of women working in a computing role who pursued an alternative path?
- What trends can be identified for some of the women trying to enter computing through alternative pathways?

Schlossberg's Transition Theory guided our inquiry as we sought answers to these RQs. We collected data from publicly available job profiles online to capture women's career trajectories. By conducting content analysis, we were able to further characterize women's trajectories — as they pertained to their education, computing-related job information, and organizational affiliations — to identify the trends that can be used to inform the computing education research (CER) community's practices to encourage more women to join.

2 LITERATURE REVIEW

Although efforts to broaden participation have expanded in the last few years [36], women continue to remain minoritized in the computing workforce [32]. The most recent Global Gender Gap

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Report by the World Economic Forum [7] indicated that women experience more significant educational and career opportunity gaps in fields where they are currently underrepresented. Literature suggests that there are better ways to engage and retain more women, but prior research has primarily focused on doing so through high school and college students [35]. Our study is novel in our expansion to explore additional populations and trajectories. It highlights the urgent need to examine alternative pathways to a career in computing, especially for women, as a potential means to address these disparities. To situate our work, we will discuss literature that explores women's occupational interest development as well as the alternative pathways often discussed in recent studies — master's degree programs, bootcamps, and MOOCs.

Recent research has suggested that low participation of women in the field may be attributed to delayed computing aspirations [15] as well as factors such as masculine stereotypes about computing [4], gender dynamics [31], and a lack of computing exposure [19]. A prior study [29] noted differences in the characteristics, attitudes, and mindsets of older women enrolled in coding bootcamps compared to younger women and girls. However, the dominant narrative in computing education is associated with prior exposure to computing or math [25], which may exacerbate the exclusion of women who form their interest in computing later in life. We should not neglect the talent of this pool of women nor the potential that alternative pathway programs present as a solution to ameliorate the situation in computing.

One such alternative pathway for post-secondary populations is the development of Master of Science (MS) programs in CS for non-computing majors. Although the details on course availability, formats offered, and the precise curriculum may vary [2, 11, 13, 16], these programs often feature a bridge or conversion component to prepare non-computing majors on core learning outcomes before delving into the graduate content in computing [16]. A commonality among the design of these degree programs is the curricular inclusion of theoretical foundations, breadth of experiences and subject matter, critical thinking, and engagement with current technology that can help candidates with their job search [20]. One of the key features of these programs is the intention to recruit a diversified student body and to allocate resources to support them during the program [2]. Students who graduate with a formal computing degree may struggle in the job search, but they may still find it easier compared to applicants who do not have a degree [11].

Meanwhile, coding "bootcamps" provide intensive training on relevant, in-demand technologies with curricula tailored to the current industry practices and technical requirements. On average, they span 17.3 weeks, and the cost is around $14,142 [6]. To better deliver the intensive curriculum in a limited timeframe, the majority of bootcamps provide in-person training. However, this has recently switched to more remote learning due to the COVID-19 pandemic. Among the alternative pathways for women to computing, it usually tops the list of selected programs since they tend to be more diverse, with a 35% female student body [5]. The annual bootcamp survey reported a job placement rate of 79% of bootcamp graduates [5]; however, prior studies demonstrated that challenges in the computing job search still remain [19, 20, 31]. The average time between bootcamp completion and the first full-time job reported is two months [31], and most bootcamp students have to adjust their expectations to a small/mid-size company after the tedious and burdensome computing job search journey [20].

Other computing-related exposure, such as self-learning through online resources, has also been identified as a potential alternative pathway in the literature. Typically, individuals turn to such sites to satiate their curiosity about coding or meet job-related demands that necessitate acquiring additional computing skills. Using various online learning resources, e.g., massive open online courses (MOOCs) or online tutorials, has been reported as a common approach for computing professionals to keep up with the most recent technologies [8]. Yet, using MOOCs to self-teach computing skills often requires strong motivation since such programs are self-paced and learning is dependent on the effort put into them. Research has explored how MOOCs can complement computing education to fill the knowledge gaps before/or after bootcamps [19, 20], but literature has rarely documented self-teaching coding through MOOCs as an alternative computing pathway. Online communities (like fandom.com) can further serve as pathways to incite women's interest in learning to code [4]. Software-end users may also develop computing aspirations as they strive to customize their software applications to meet their own business needs [14].

The programs mentioned above have previously been described in literature; however, it is not an exhaustive list. The first step for us to build a solid understanding of the experiences encountered on the path to a computing career requires capturing the landscape of alternative computing pathways available. Furthermore, the topic of alternative pathway programs has not been characterized with respect to a focus on women. We seek to fill the gap through this pilot study by investigating the types and features of alternative pathways commonly chosen by women.

3 THEORETICAL FRAMEWORK

We used Schlossberg's Transition Theory as a theoretical lens to facilitate our understanding of women's transition to the computing workforce. This theory, created with an emphasis on adult development, investigates how people identify and adapt in response to transitions [9, 27, 28]. According to Schlossberg, there are three types of transitions: anticipated, unanticipated, and non-event. ***Unanticipated events*** are those that occur unexpectedly, whereas ***anticipated events*** are those that occur predictably. ***Non-events*** are events that were expected to occur but did not occur. As shown in Figure 1, three stages have been involved in the transitions: moving in, through, or out. This theory includes the 4S System (self, situation, support, and strategies) to emphasize the importance of an individual's perception in transitions [1].

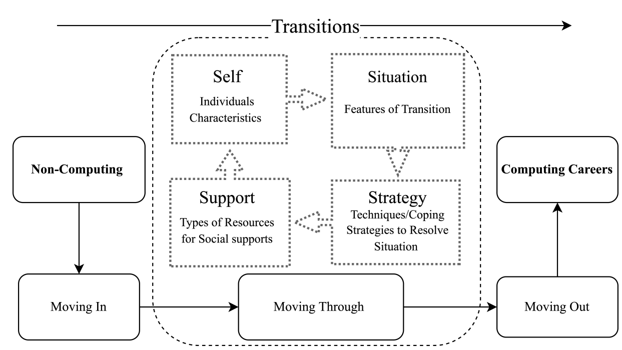

Figure 1: Transition Model, Adapted from Schlossberg

Using this framework, we characterized the computing career pursuits of women with a focus on "self," "situation," and "strategies." The limited amount of information collected prevented us from making inferences about "support" through the current study. Our application focused on contextualizing the "self" and "situation" aspects described in theory by capturing details about women's non-computing backgrounds. This theory describes that during a transition, individuals may experience a state of confusion and disorientation called "transition shocks" [9]. Depending on the different alternative pathways women choose, the transition shocks they may face could impact their perceptions of transition experiences and lead to different "strategy" choices. We further explored the "strategy" by documenting computing-related educational and professional development activities to set the scene for varied transitional experiences. This serves as a preamble to help us further evaluate the effects of transitional experiences from different alternative paths on women's career aspirations toward computing.

4 METHODS

To systematically summarize women's alternative pathways to a computing career, we conducted a digital content analysis by evaluating their publicly available job profiles on LinkedIn. The search terms and locations applied were based on previous work that explored the top five cities for technology-related positions and the top five computing job titles in the U.S. [18]. We first collected the potential profiles of 10 women per city for each job position, resulting in a total of 250 profiles. We then applied sampling criteria to these profiles and elected to only include participants who possessed extensive experience in the phenomenon under study [23]. The specific standards for selecting the participants included that they were: 1) women; 2) currently working in a computing career; and 3) received a bachelor's degree in any field other than computing. Since LinkedIn users are not required to display their gender identification, we relied on the self-selected pronouns articulated on their profile. For those who did not list any pronouns, we manually examined the individual's summary and/or recommendations received. We only included profiles that met the conditions for further analysis. After applying the selection requirements, we funneled the total down to 139 profiles of women currently working in computing occupations through an alternative pathway.

Studies in computing education have applied content analysis to present trends in engineering and computing education previously [21, 34]. This method typically involves quantifying qualitative data and identifying patterns and trends in the context of the presented documents. A "codebook" of themes pertinent to this study was created and used to categorize the job profiles. We defined ***computing-related touchpoints*** as any moments in time where women might gain exposure to computing, including items such as learning (e.g., displays of certificates achieved in online courses), internships, job descriptions, and/or participation in computing groups. We followed the method described by Hsieh [10] to investigate each of the job profiles and to determine which computing-related touchpoints were applicable after their undergraduate degree through additional education or work experience. We focused on mining the education and work experience described by their profiles and created a detailed tabulated list to summarize the information. The data and themes collected are described in Table 1.

Table 1: Themes Collected from Job Profiles

Categories	Themes	Description	Examples
Educational Experiences	Degree Program	All the degree level and majors received	First Degree: Bachelor in Statistics Second Degree: Master in Engineering Third Degree: N/A
	Bootcamps	Any intensive program offered with month-length	Codeacadmy: Software Engineering Bootcamp
	Massive Open Online Courses (MOOCs)	Any online resources related to computing topics	Coursera: Introduction to Python
Working experiences	First Job	Titles and professional organizations for first full-time computing positions	First Job: data analyst xx company
	Current Job	Titles and professional organizations for current full-time computing positions	Current Job: data scientist xx company
Other experiences	Other Computing-related Touchpoints	Any additional activities that have exposure to computing	Internship, research assistant, non-degree certificate program, computing social groups, etc.

We want to disclose some of the choices made during the data analysis that could impact the outcome. First, we labeled each profile with a boolean "0" or "1" to indicate the presence of any related alternative pathway program. We only considered it present (labeled "1") if the individual self-reported an experience described by the theme categories listed. However, we want to caution that job profiles are based on publicly listed information, and therefore a "0" may not indicate that the individual did not have the experience but instead could merely signal it was not an experience publicly shared. Next, some profiles reported having formal educational experiences through online schools but without an official degree. By further investigating these programs' structure and format, we categorized them as follows: 1) bootcamps if the program was offered for no more than 6 months and was in an intensive format; 2) non-degree certificate programs if completion was estimated to take 6 months or more and did not offer an intensive curriculum. Lastly, alternative pathway programs were characterized by an individual's transition from a non-computing degree before entering the computing job market. We further grouped the profiles according to what they defined as the subject of their first undergraduate degree, what they listed for their second degree (undergraduate or graduate, as appropriate), and third or fourth degree(s) (when applicable). We only considered those who transitioned to computing upon completing their first undergraduate degree in a non-computing field. Utilizing Schlossberg's theory as our analytical lens, we elected to include the second degree and any subsequent degrees listed as the job entry point to better capture the non-computing backgrounds and the dynamic processes that might result in a woman's pursuit of a computing career.

To better characterize the alternative pathway programs and to avoid double-counting, we grouped education and work experiences. The educational backgrounds collected through this analysis were sorted into major categories as shown in Table 2. To capture the themes of the non-computing backgrounds, degree program majors were classified as computing, engineering, other STEM (referring to those in science, technology, engineering, and mathematics), non-STEM, and interdisciplinary. Our data were collected from women working in computing-related roles with specific titles. This approach resulted in the inclusion of women in our dataset who

Table 2: Themes for Education Backgrounds

Theme	Description and Examples
Computing	Computing-related fields in the STEM major list computer science, computer engineering, information technology, data science, information sciences, etc.
Engineering	Engineering related fields in the STEM major list electrical engineering, material engineering, mechanical engineering other engineering, etc.
Other STEM	Other technology/science-related fields in the STEM major list Mathematics, Statistics, Psychology, Medicine/Health, Biology, etc.
Non-STEM	Business related fields Other Non-STEM fields English, Media studies, etc.
Interdisciplinary	Majors with two or more fields from two themes. Economics & Mathematics, Physics & Arts, Economics & Psychology, etc.

were all working in computing or technical roles but who may have differed in their corporate affiliations. Thus, we further categorized the companies' information into three themes including: Big tech, Other tech, and Non-tech. The detailed descriptions and examples are listed in Table 3. We focused on capturing their current position and company and their first CS-related position and company to investigate any career changes in between.

Table 3: Themes for Companies Types

Theme	Description & Example
Big Tech	Organizations listed on the top 20 tech company list
Other Tech	Tech companies not on the top 20 tech company list
Non Tech	Companies in traditional industries

5 RESULTS

When exploring career trajectories, we noted that women's exact alternative pathways varied on a case-by-case basis. Employing the content analysis approach to examine the 139 job profiles, we identified patterns for bachelor's degree-holding women who entered a computing career through an alternative pathway. We observed that women may obtain additional computing degrees from higher education institutions, although they may also hone their skills through coding bootcamps and self-learning through online resources. As shown in Figure 2, 46 out of 139 reported degrees in computing fields, 34 had bootcamp experiences, and 39 described learning via MOOCs. Usually, the women selected either a degree program or a bootcamp as the alternative pathway program to enter a computing position. Two profiles listed both experiences (a degree in computing along with a bootcamp). We want to point out that women may also combine MOOCs with an alternative pathway experience to keep up with the latest technology required for computing positions. Out of all the participants, 9 reported bootcamp and MOOCs experiences, and 13 profiles mentioned a computing degree and MOOCs.

To delve deeper into the trajectories of the women, we separated their educational backgrounds into the three phases already mentioned (see Section 4 above). Figure 3 displays the transitions between the women's educational phases. The majority of women (110 out of 139) who are working in computing roles chose to obtain a second degree before they joined the computing workforce. Their computing career entry point began after obtaining a second degree

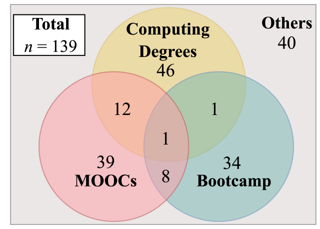

Figure 2: Alternative Pathways Reported

for 117 women, and only 22 decided to pursue additional degrees. Women were more likely to choose a second degree in computing, as reported by 37 women, followed by 36 for non-STEM majors, and 29 for other STEM majors. Of those in the participant group, 29 entered the job market at this stage. As for those that continued to pursue degrees, 10 of them were computing majors, 8 were in other STEM fields, and 4 majored in non-STEM disciplines.

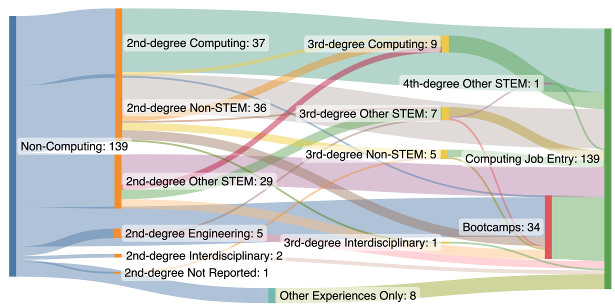

Figure 3: Major Career Trajectories

We also identified trends for women who entered computing through alternative pathways as a result of the other computing-related touchpoints (Figure 4). The Master of Science in Computer Science program offered by Northeastern University and the Master of Science in Computer Information Technology program were two frequently mentioned degree programs, in the scope of this study. As for the coding bootcamps, General Assembly[1], App Academy[2], Fullstack Academy[3], and Flatiron School [4] were the top mentions. Two additional unique bootcamps are worth mentioning: a) Insight Data Science Fellow[5] is designed for doctoral degree holders, to cultivate the practical skills needed to become a data scientist; and b) the Grace Hopper program offered through Fullstack Academy, which offers immersive bootcamp experiences for women and students (including trans and non-binary individuals)[6].

We further investigated the non-computing educational backgrounds to understand the most common paths taken by women working in a computing career. The majority of the women (60 of 139) held non-STEM degrees, 51 came from other STEM, 18 came from engineering, and 6 were interdisciplinary for their first degree. Our results indicated that women switchers often majored in other STEM fields such as mathematics, statistics, and electronic engineering, as shown in Table 4. Similarly, the top major choices for women who obtained a second degree were computer science, statistics, and data science. Moreover, we discovered that data science

[1] https://generalassemb.ly
[2] https://www.appacademy.io/
[3] https://www.fullstackacademy.com/
[4] https://flatironschool.com
[5] https://insightfellows.com/data-science
[6] https://www.gracehopper.com/

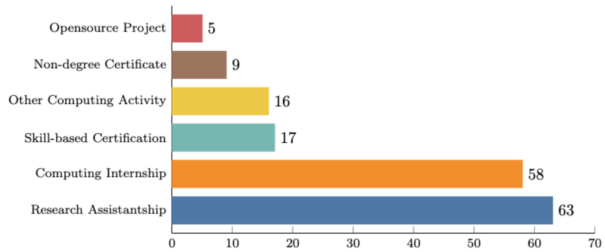

Figure 4: Other Computing-related Touchpoints

programs were frequently pursued by women with first degrees in business, particularly in the context of data science or machine learning/artificial intelligence-related jobs.

Table 4: Top Five Majors between First and Second degrees

First Degree	Counts	Second Degree	Counts
Mathematics	14	Computer Science	19
Biology	11	Statistics	13
Electronic Engineering	10	Data Science	10
Statistics	7	Business Analytics	9
Business	7	Economics	4
Economics & Math	6	Finance Engineering	4

We also observed patterns in the types of companies selected when women entered the computing workforce. As already described in Table 3, the current company affiliation and the first computing role in a computing job were divided into three separate categories. Yet the proportion of women affiliated with working at big tech companies (28.78%) was smaller than that of women in other tech (33.09%) and non-tech (26.62%) companies (see Figure 5). After gaining working experience in computing roles, the percentage of women working at big tech companies increased to 40.29%. Similarly, for current positions there were 32.37% at other tech companies and the portion decreased to 26.26% for those who were working for non-tech companies.

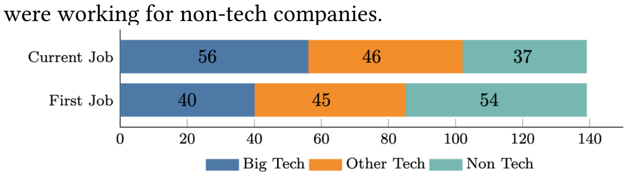

Figure 5: First Job VS. Current Job by Company Type

6 DISCUSSION

We interpreted our results using Schlossberg's model [27], which suggests that women may adapt to their transition into a computing career through alternative pathways differently, considering a 4S system of self, situation, support, and strategy. We conceptualize this in the context of how developing a career in computing could be impacted by how women deal with their own transitions. In this study, we observed that women may obtain additional degrees in computing from higher education institutions, although they may also hone their skills through coding bootcamps and/or self-learning through online resources. Below, we consider each of the 4S items separately and then present the implications and offer future guidance. Note that we do not include support since this was beyond the scope of what we could glean from online profiles.

Self: The first step to understanding a transition is to capture the unique "self" of the women who entered computing later in their career path. The majority of them majored in STEM disciplines, predominantly in mathematics. As math exposure is often attributed to computing interests [25], we posit that women with a strong foundation in math may face fewer obstacles when trying to switch to a computing-related major. This finding has been further supported by a prior study indicating that computing- or STEM-related knowledge impacts women's self-efficacy through positive learning experiences in programs [11]. In alignment with this, Schlossberg's theory emphasizes a positive or optimistic attitude is essential to overcoming "transition shocks" that may arise with transitions. Accordingly, we hypothesize that engaging women with non-computing backgrounds through computing touchpoints could enhance their self-efficacy. These touchpoints may reinforce positive attitudes and feelings of accomplishment, which could encourage women to survive transition shocks and strengthen their computing career aspirations. We aim to explore how women may overcome transition shocks through computing touchpoints using qualitative analysis in the future. The current findings provide a foundation for capturing the contexts of women's transitions into computing through alternative pathways.

Situations and Strategies: To understand how different "situations" vary using "strategies" to facilitate the transition into computing, we compared two common choices of alternative pathways, degree programs and bootcamps. We want to emphasize that the curriculum for each is designed for very different learning outcomes. Degree programs in computing fields require theoretical foundations, critical thinking, and subject matter technical competencies [20]. Meanwhile, bootcamps tend to focus on au courant technologies, and the topics are primarily centered on helping students survive technical interviews [6]. The different foci directly contribute to the varied time commitments expected by these pathways. Bootcamps often require a dedicated period of time with a high level of intensity. Comparatively, degree programs are more prolonged but less intense throughout the program. Another distinction, supported by prior studies [19, 31], is that women who complete bootcamps may struggle to land jobs at big tech companies. In this situation, landing a job at big tech through a bootcamp becomes a "non-event," as described by Schlossberg [27]. One strategy employed to deal with such an event potentially is to first begin by working for small/mid-size companies. A possible explanation for this phenomenon is the differences in timing for internships. For degree programs, computing internships are often offered during the summer between academic years for students to practice the technical skills required on-the-job. If any skill gaps are identified during the summer internship, students can fill them by taking relevant courses when returning to campus. Contrarily, for bootcamp students, internships were always hosted after or towards the end of the program. If participants develop further learning needs, they must rely on self-learning through MOOCs, attend another bootcamp, or even pursue a computing degree to resolve knowledge deficiencies.

Key Findings: One major finding from our analysis was the preponderance of women who mentioned having experience as a Research Assistant (RA) at the undergraduate level. This experience at the "moving in" stage could be one potential way to form a positive "self" which inspires a later interest in computing. Lacking exposure to computing has been identified as a common deterrent that may delay women's interest in computing [19]. However, the RA experiences could fill this gap, especially for those coming from another STEM major. For example, some profiles indicated using computational modeling for machine learning and natural language processing to assist biology and psychology research projects. Whereas women perceive computing to be less relevant to "helping others" than other STEM fields, recruiting women from other STEM disciplines using computing has been identified as one potential path [24]. Social values of "helping others" have previously been linked to career aspirations [15]. As such, research experiences in other STEM fields could provide an opportunity to make connections between these values and computing [26].

Implications to Interested Women: This study identified a number of themes and trends that have practical implications for women interested in a computing career or in the process of seeking to enter. It should be emphasized that the choice of alternative pathway programs could impact career outcomes. For those seeking a position with a big tech company (e.g., Google, Microsoft, etc.), choosing a degree program might better serve this need. Meanwhile, an individual might struggle to fit into the male-dominant computing culture present within the learning environment of such degree programs [11, 31]. For those interested in working in a computing-related role without preference for a company or industry, bootcamps can rapidly develop the foundations needed to transition into a computing career within several weeks. Some unique versions, such as women-focused bootcamps, may offer a more inclusive learning environment and additional support to facilitate a smoother transition into a computing career. However, it is important to be aware of the high level of intensity in bootcamps since they can be demanding, particularly for those juggling multiple life roles.

Call to Action: It is critical to expand CER to consider additional inquiries into women who continue to develop their career aspirations with a different conceptualization of "self" as they enter the discipline. We suggest an examination of the different computing touchpoints achieved through an alternative pathway and delving into the "strategies" employed to overcome obstacles during the transition. Going forward, we also recommend the following actions for educators to attract more women into computing. First of all, flexible program offerings may be better tailored to women's needs, particularly those seeking to pursue a computing career later in life. A remote learning format may assist them in balancing their other life role responsibilities, such as being the primary caretaker for the family or potentially needing childcare. Second, the growing demand for computational skills has expanded into higher education [37], the social sciences [3], business [30], and so forth. As discussed, we might be able to inspire more women by offering a computing track or minor to other STEM or non-STEM majors. Furthermore, internships allow students to test out what they have learned and identify any skill gaps while still in school. Programs with strong industry relationships may become more appealing to those women with company or industry preferences. Lastly, educators should continue cultivating inclusive and women-friendly computing learning environments by incorporating more computing-related activities, such as research assistantships, teaching assistantships, computing social clubs, etc. Studies have shown that such activities not only increase computing exposure to raise computing awareness and interest [17, 25], but they can also help strengthen their computing identities to encourage them to persist in the field.

7 LIMITATIONS

As with any study, there are limitations. This research is not a comprehensive investigation of all the job profiles of women who entered computing through alternative pathways. We acknowledge that 139 profiles are insufficient to describe all of the alternative pathways women may employ. Findings or claims made here should only serve as a precursor to inform the development of more in-depth studies.

In addition, we utilized publicly accessible job profiles and the details posted were self-reported at the individual's discretion. Consequently, we can only speculate about potential choices for those themes labeled "0" for not available since this information was not disclosed. People may selectively share to improve their perceptions. We suggest future work consider expanding upon the approach described to gain additional insight into these women's experiences and motivations. Furthermore, the profile data also affects the type and extent of data reported. For example, we cannot capture any social interactions outside of the alternative pathway programs that could contribute to the formation of computing career aspirations. This limits our ability to inquire about the "support" and other related aspects of the 4S suggested by transition theory [1, 27]. Going forward, we hope to address this by adopting other qualitative research methods. Lastly, this exploratory study limits our ability to understand women's behaviors and interactions throughout their trajectory and how well they utilized Schlossberg's 4S system to deal with the transitions when pursuing a computing career. We recommend follow-up studies consider these areas.

8 CONCLUSION

Our pilot study used content analysis to examine the types of pathways common for women who enter computing later in their careers. Previously, limited research focused on alternative pathways for women who did not obtain their initial bachelor's degree in computing. Exploring descriptions of their trajectories is the first step for us to develop strategies to further engage with this population to encourage gender parity in the computing workforce worldwide. In this paper, we offered suggestions that deliberately consider women who professionally pursue their interest in computing later in life. We provided a guide for women seeking to choose an alternative pathway program so that they can select one that best serves their needs. Last but not least, we proposed actionable recommendations for educators to engage and continue to retain women in the computing workforce. It cannot be overstated how critical it is to think about the settings and culture we create in academia and the technology industry and to establish inclusive and welcoming environments.

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