Re-Entering Computing through Emerging Technology: Current State and Special Issue Introduction

FARZANA RAHMAN, Department of Electrical Engineering and Computer Science, Syracuse University, USA
ELODIE BILLIONNIERE, School of Engineering & Technology, Miami Dade College, USA

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1 INTRODUCTION

Recruitment, retention, and graduation of women in the computing disciplines are critical needs in our nation. Research suggests that women drop out of academic programs and leave the workforce to care for their immediate or extended families, to address financial setbacks, to meet personal obligations, and to respond to active-duty calls [1]. Hence, returning women remain one of the largest untapped talent pools in the nation to fulfill the growing demand of computing jobs [2]. Returning women rarely choose to pursue computing education or cannot get into the computing profession for various reasons [3–6]. These include the following: (1) the field of computing is constantly evolving; (2) academic computing degree programs have a rigid structure and require specific backgrounds; (3) technical skills development can be time consuming and challenging; (4) there are not enough transitional programs that can leverage the existing background of returning women to develop new knowledge, and (5) the computing industry and academic programs have few and limited re-entry pathways to prepare returning women for the real-world job market. This special issue presents original research results that evaluate educational interventions and new pathways that have positively impacted women's re-entry into computing education and careers and that appeal to a broad audience interested in exploring, designing, and developing re-entry initiatives related to computing education.

Authors' addresses: F. Rahman, Department of Electrical Engineering and Computer Science, Syracuse University 223 Link Hall #377B, Syracuse, NY 13244 USA; email: frahma02@syr.edu; E. Billionniere, School of Engineering & Technology, Miami Dade College, 627 SW 27th Ave #6025-19 Miami, FL 33135 USA; email: ebillion@mdc.edu.

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1.1 Background

The STEM workforce in the United States has grown rapidly since the late 2000s. A large percentage of the increase in STEM jobs has occurred in computer-related and technology-based occupations. Over the next few decades, the computing job industry is projected to expand at an exponential rate [7], opening up millions of computing job opportunities for the current and next generation [8]. As the demand for computing and tech professionals outpaces the supply of skilled workers, there have been numerous efforts to fill the void. Nonetheless, the computing industry continues to struggle to keep up with the demand of workforce and also suffers from the underrepresentation of women [9].

The issue of underrepresentation of women in the computing industry has been widely recognized for many years. Additionally, the COVID-19 pandemic has left more than 31 million Americans unemployed [10], and a large percentage of these layoffs has the potential to become permanent, which will certainly create more inequality in the computing industry [11–13]. The computing and tech job gap throughout the nation can be fulfilled by creating opportunities for the largest untapped talent pool: returning women. Since the late 2000s, many initiatives have focused on diversifying the computing and tech workforce on the assumption that the only issue of underrepresentation of women in computing is the leaky pipeline. Little attention has been paid to returning women who can fill the gaps in the computing and tech industry in coming years.

However, too many returning women lack knowledge of the variety of paths to computing and tech professions. Many returning adult students also lack college-readiness skills and knowledge to successfully pursue traditional computing degrees. Hence, to broaden participation and fill a growing need in the computing and tech workforce, it is important to shift the community's focus to the design, development, and evaluation of innovative (re-)entry pathways that allow returning women to enter computing academic and professional pipeline beyond the traditional academic setting [14].

1.2 Articles Presented in the Special Issue

The seven articles in this special issue present empirical and theory-based research involving qualitative or quantitative analysis that aim to expand the current knowledge base on women's experiences, their strategies as they navigate computing career pathways, and their challenges in working in computing fields.

For decades, there have been calls to action to improve the representation of women and minoritized racial/ethnic groups in computing. Despite these efforts, there remains a lack of diversity and a need to broaden participation. Although prior literature has begun to examine the factors that impact engagement and retention, too often gender, race, and ethnicity are considered separately. This division tends to overgeneralize findings and minimizes the understanding of oppressive and discriminatory concerns and experiences that may arise from the intersection of social identities. The article that opens the special issue, titled "Exploration of Intersectionality and Computer Science Demographics: Understanding the Historical Context of Shifts in Participation," by Lunn et al., explores enrollment and graduation trends between 1987 and 2018 for computing students, using the Multiple-Institution Database for Investigating Engineering Longitudinal Development, a longitudinal database spanning 19 institutions. Their analysis includes disaggregation of the data to gain insight into intersectional populations often omitted due to small numbers. They conducted historical context analysis to provide illumination into the vicissitudes in participation of women, and particularly Black women, Hispanic women or Latinas, Native American women, and Asian women. Their study describes the historical efforts undertaken previously, and the potential political, social, and economic influences that may have impacted these groups. The

findings demonstrate the importance of considering the needs of different students and reifies that the computing education community, still has a long way to go to create a more equitable field.

The necessity for a steady STEM workforce has prompted academia to develop strategies to encourage people of diverse backgrounds to enter STEM fields. A bridge program, also known as a conversion program, offers alternative pathways for individuals who have no prior computing education to receive the education that can help in developing their careers or acquiring a graduate-level degree in computing fields. The next article, titled "Crossing the Bridge to STEM: Retaining Women Students in an Online CS Conversion Program," by Hsu and Memon, presents an online CS bridge program offered by their institution and highlights the findings of research they conducted to evaluate and improve the online program.

As the lack of women in technology is splashed across the news, the response of some working women has been to volunteer their time and effort not only to learn to become software developers themselves but also to help other women do so. One intriguing setting for this push to create a more gender-balanced workforce is the (largely virtual) community that has been born around the use of the Salesforce platform at many companies—among them many nonprofits. This community is nurtured by the ethos of working collaboratively in an atmosphere of trust promoted by the Salesforce company, and the ability to help one another learn is enabled by the work on a common platform. The third article of the special issue, titled "Arising of Informal Women's Learn-to-Code Communities: Activity Systems as Incubators," by Lyon and Clayton, takes an ethnographic approach to studying a grassroots informal learning group that arose when several women put their heads together at the Dreamforce conference and decided to plan and run a set of women-helping-women classes to teach each other to be developers on the Salesforce platform. They studied one 10-week series of coaching and learning sessions run by this group, using activity systems analysis to better understand the learning and outcomes for women involved.

Women returning to the workforce are not a demographic typically planned for in hackathons, the time-bound collaborative project-based computer science competitions often held on college campuses. Although there are many benefits of hackathon participation in terms of education and career connections, the next article of the special issue, "Gender Differences in Hackathons as a Non-traditional Educational Experience," by Hardin, presents a mixed-methods study of three hackathons, and over 46,000 surveys found that there were demographic differences in how participants were able to access these benefits. Recommendations for improving hackathons are subsequently discussed.

Unfortunately, women too often discover that they are interested in working in computing at a life stage that is too late for them to complete a college degree in computer science. If these women could be given opportunities to learn what they need to obtain and succeed at technology jobs, then there would be a chance to increase diversity in the computing workplace. That is the central focus of the next article of the special issue. The article "Coding Boot Camps: Enabling Women to Enter Computing Professions," by Lyon and Green, investigates one category of training setting attempting just that: the coding boot camp. The authors report on a qualitative study focusing on women completing boot camp training. They contrast these participants with men at boot camps and women in university computer science programs. They contextualize the computing ecosystem through data collected and analyzed from industry hiring managers, boot camp representatives, and university computer science faculty. Their findings demonstrate that that training at a boot camp can be the catalyst for college-educated women to attain computing jobs and careers, although these entry-level jobs may be a compromise to the goal of a software development job and are unlikely to lead to a job at large, well-known, established technology companies.

Professional women who never learned to program have a growing desire to learn how to code. Despite the research efforts focused on younger populations (e.g., K-12), these individuals may have many opportunities to benefit from enhanced skills and attitudes about computer programming. The article "After-Hours Learning: Workshops for Professional Women to Learn Web Development," by Peña et al., created and evaluated the impacts of a 9-week web development workshop with a carefully designed learning space boasting comfort and safety for this population. The authors reported how the professionals' attitudes and skills increased over time and the implications of their participation in their lives.

The last article of the special issue, titled "Informal Technology Education for Women Transitioning from Incarceration," by Seo et al., discusses how an interdisciplinary team developed and implemented a technology education program for women who have been recently released from jail or prison and are seeking to reenter the workforce (women-in-transition). Women-in-transition are particularly marginalized in terms of technology education, as they stand at the intersection of not only being women but also often being ethnic minorities and economically disadvantaged. About two-thirds of women presently incarcerated are women of color, with more than 60% of them Black or Hispanic. Most of all, these women are largely isolated from digital technologies while being incarcerated. The research team's interviews with 75 women-in-transition identify specific challenges and barriers facing these women as they try to acquire digital skillsets. In particular, the findings show that those building technology education programs for women-in-transition should take into account social-psychological factors such as low self-efficacy as well as precarious financial situations. The lessons learned from the team's transition from in-person sessions before the outbreak of the COVID-19 pandemic to online-only settings during the pandemic provide helpful insights for online curriculum development in this area.

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