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Original Paper

Systematic Efforts to Actualize Sustained Diversity, Equity, and Inclusion in Computing Disciplines

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Abstract

The persistent underrepresentation of women, racial and ethnic minorities, and marginalized groups in computing fields highlights the need for sustained, systemic efforts to advance diversity, equity, and inclusion (DEI). This paper explores strategic approaches to embedding DEI into the institutional frameworks of higher education computing disciplines, emphasizing the sustainability of these efforts. It examines existing barriers to inclusion and presents evidence-based recommendations for fostering sustained change through policy reform, long-term mentorship, inclusive curricula, and leadership accountability. The authors emphasize the need for collaborative partnerships with K-12 institutions and community organizations; the paper also outlines pathways for expanding access to computing education for historically marginalized populations. Finally, continuous learning and adaptation are discussed as vital components for ensuring that DEI efforts remain dynamic and responsive to evolving challenges. The paper concludes by arguing that achieving true diversity in computing requires a comprehensive, long-term commitment to dismantling structural inequities, creating inclusive environments, and fostering a culture where all voices contribute to innovation and problem-solving, thereby ensuring that diversity efforts are not only impactful but also sustainable over time.

Keywords: diversity, marginalized populations, computer science, culturally responsive pedagogy, mentorship

1. Introduction

The journey toward achieving diversity, equity, and inclusion (DEI) in computing requires an ongoing commitment that extends beyond initial interventions. While short-term initiatives are valuable in raising awareness and fostering inclusion, long-term sustainability requires a more strategic approach that integrates systemic changes into the fabric of computing education, research, and professional practice (Nakajima et al., 2024). To ensure sustained impact, institutions and organizations must focus on multi-layered efforts that address the underlying barriers to inclusion and cultivate an inclusive culture for all. As stated in the Association for Computing Machinery DEI resources webpage.

> There is a *movement* occurring broadly across many scientific and engineering fields, including widely within our computing community, toward making tangible progress through intentional actions and interventions for advancing and valuing diversity, equity, and inclusion. There is also a parallel movement toward dismantling structural and/or systemic factors-especially but not limited to racial and gender biases-that may be standing in the way of making much-needed progress in advancing and valuing diversity, equity, and inclusion fully. Similar to those in other technical fields, we as a computing community are faced with the persistent key question: *What*

more can and should be done? (Pinkston, 2024, para. 1)

In this paper, we discuss the conceptual, theoretical, and practical bases for sustaining efforts to support diversity in computing disciplines. We address the current state of workforce diversity in the computing disciplines. We then recommend ways to support diversity, including making policy and structural changes, creating long-term mentorship and support networks, incorporating culturally relevant and responsive pedagogical practices, encouraging leadership commitment and accountability practices, establishing collaborative partnerships and community engagement, and supporting continuous learning and adaptation as ways to achieve and maintain diversity in computing fields. We conclude with a discussion regarding how the implementation of these policies and procedures in an integrative manner can support sustainability in DEI in computing disciplines.

2. Current State of Workforce Diversity in the Computing Disciplines

The underrepresentation of women and minorities in undergraduate courses in the computing disciplines (i.e., computer science, computer engineering, cybersecurity, information systems, information technology, and software engineering; Association for Computing Machinery, 2024) is an ongoing concern, with the gap between men and women pursuing advanced computing degrees even wider than at the undergraduate level. Moreover, more men than women who earn computing degrees actually enter into the computing workforce, with women often choosing careers that they perceive as having fewer gender disparities, less discrimination, and greater attention to diversity, as well as choosing those careers that are more family- or quality-of-life-friendly (e.g., Funk & Parker, 2018; Sanders, 2021).

Indeed, the underrepresentation of women and minorities in computer science compared to other STEM disciplines is stark (National Center for Science and Engineering Statistics [NCSES], 2023). Across STEM disciplines, 50% of the bachelor's degrees are awarded to women. In computer science, however, only 21% are awarded to women, a slight increase from 18% in 2011 but lower than the 29% awarded in 1995. Across STEM disciplines, 26% of the bachelor's degrees are awarded to individuals from underrepresented minority groups, such as Hispanic or Latinx, Black or African American, and American Indian or Alaska Native groups. In computer science, only 19% are awarded to underrepresented minority groups, the same percentage as in 2011 and close to the 18% awarded in 1995 (NCSES, 2023). Within these groups, only 9% of computing degrees are awarded to African American students (Beckman, 2023), and only 1% of Native American students receive associate degrees in computer science, with only 0.4% receiving bachelor's degrees (McAlear et al., 2023). Moreover, researchers have found that women hold only 25% of all computing-related occupations, and while Black and Hispanic people comprise 13% and 18% of the US workforce, they hold only 7% to 8% of the jobs in computing disciplines (Newsome, 2022; Statista, 2023). Thus, rather than being immutable, representation in the computing disciplines is malleable and amenable to structural and systemic change, if those levers of change can be identified, implemented and sustained.

3. Policy and Structural Changes

Sustaining diversity efforts begins with embedding equity into policies and institutional frameworks (May & Bridger, 2010). This includes revisiting recruitment, hiring, promotion, and retention practices to ensure that historically underrepresented groups in computing—such as women, Black, Indigenous, and other people of color (BIPOC), and individuals from low-income backgrounds—have equitable access to opportunities. Developing clear policies that address unconscious bias, microaggressions, and other forms of discrimination can create a more welcoming environment and reinforce a commitment to diversity at every level.

4. Long-term Mentorship and Support Networks

Mentorship plays a crucial role in retaining diverse talent within the computing field. Sustainable diversity efforts should incorporate formalized mentorship programs that extend beyond initial entry points, providing guidance and support at critical career junctures (Davidson & Foster-Johnson, 2001; Turner et al., 2023). Creating communities of support—through affinity groups, peer mentoring, and professional networks—helps marginalized individuals feel valued and understood, fostering a sense of belonging that is vital for long-term retention and improving their well-being (Appleseth et al., 2023; Baker & Lattuca, 2010; Chen Musgrove et al., 2024; Williams et al., 2022).

Efforts to recruit from diverse communities require outreach, persistence, and collaboration with community partners. Establishing trust with leaders and community members who guide and support mentoring efforts is key to recruiting and supporting diverse individuals as they prepare for and enter into computing occupations. Establishing methods appropriate to ascertaining the most salient barriers to computing careers that are specific to both diverse community members and diverse individuals is critical to addressing those barriers. Ongoing focus groups and interviews with computing professionals from diverse backgrounds, as well as educators, managers, and computing students can inform both individual and systemic interventions that will support highly impactful DEI work (e.g., Charleston, 2012; Charleston et al., 2014). Individual assessments of barriers using measures such as McWhirter's Perceptions of Educational Barriers Scale (McWhirter et al., 2000; Turner et al., 2022) to the pursuit of a computing career can help tailor DEI efforts so that they can help ensure the success of individuals from diverse communities in the computing professions.

At the K-12 and university levels, encouraging parent, peer, and faculty mentoring and support for students is critical as we continue to construct models that not only identify barriers to DEI, but also ensure that students in computing disciplines will successfully overcome these barriers in pursuit of their educational and career goals (Cohoon et al., 2004; Turner et al., 2022). Whole university efforts that are coordinated, and that undergird mentorship and support policies, can ensure greater student success (Luna & Prieto, 2009; Phelps-Ward & DeAngelo, 2016), leading to greater long-term diversity in the workplace. Connecting students with professional mentors from diverse backgrounds can provide role modeling as well as guidance for how they can enter into and work in a profession that has not been historically inclusive nor minority or gender-diverse welcoming (Charleston, 2012).

As students enter into their professions, either via pre-degree internships or upon graduation, collaborating with organizations to establish mentoring programs with incentives for both mentors and mentees can bring much-needed diversity into the computer fields. Mentors with similar backgrounds and characteristics (e.g., SES, ethnicity, gender) can provide entering and new professionals with guidance to navigate work environments (Davis et al., 2023). Mentoring allies who can support and advocate for individuals from diverse and underrepresented groups can bring into focus stronger workplace relationships centered on career progression, greater demographic workplace representation, and a greater sense of inclusion and belonging for employees who may more often than not be marginalized in the workplace (Thomas-Petit, 2024).

5. Culturally Relevant Pedagogy

Sustained diversity requires rethinking the computing curriculum to reflect a broader set of perspectives and experiences. Ladson-Billings (1995) proposed a theory of culturally relevant pedagogy with three main tenets: academic success, cultural competence, and critical consciousness. Academic success includes a rigorous curriculum with support for student learning. Cultural competence includes fostering students' positive cultural identity. Critical consciousness includes recognizing, critiquing, and interrupting social injustices. Morrison et al. (2008) synthesized how the three tenets of culturally relevant pedagogy have been operationalized in classrooms. An example of putting culturally relevant pedagogy into practice in a computing sciences classroom is provided below.

A rigorous curriculum will not result in student achievement without adequate support (Morrison et al., 2008). A computing sciences educator employing culturally relevant pedagogy would clearly outline assignment expectations by, for example, providing a rubric and model student work, explicitly identifying strengths and weaknesses. They would scaffold assignments, providing smaller assignments with timely feedback to build student self-efficacy and build on those assignments larger and more difficult projects. Educators would be available to students to guide not just their academic growth but also their social-emotional learning, during and in addition to regular student drop-in hours and time in the classroom. They would communicate through words and actions their high academic and behavioral expectations of their students and they would reiterate these expectations when necessary. They would exercise determination in helping students succeed and celebrate their students' successes.

Specific courses would promote inclusivity through their pedagogical approaches, combining lectures, workshops, mentorship, and teamwork. Students would collaborate in diverse teams to tackle real-world challenges, fostering an environment where varied perspectives are essential to solving complex

problems and building a sense of belonging. By the end of these courses, students will have completed a research project, enhancing their critical thinking, problem-solving, and teamwork skills, while preparing them for advanced opportunities such as honors theses, graduate studies, and careers in research and development. Culturally relevant teaching does not reduce rigor, but provides the foundation for students to achieve in rigorous courses and a rigorous curriculum.

Cultural competence involves creating a synergy between students' community cultures and the classroom culture (Morrison et al., 2008). By integrating diverse role models, case studies, and contributions from underrepresented groups into course content, educators can show students that computing is not a monolith, but a field shaped by many. Students and community members from marginalized communities sharing their experiences with the use of computing in their cultures offers students a unique opportunity to understand real-world challenges firsthand. Furthermore, inclusive teaching practices—such as active learning, collaborative work, and flexible assessments—can help bridge the gap for students who may face barriers to traditional instruction methods (Singh & Pallai, 2023).

A culturally relevant computing sciences course offers an inclusive and practical learning experience. Students engage in hands-on research within the field of computing, working directly with healthcare facilities or other institutions. They learn essential research design, methodology, and analysis techniques while collaborating on real-world projects. By allowing students to develop and execute original research in partnership with professionals and community institutions, this type of course provides an opportunity to apply computing knowledge to challenges in healthcare, a field where equity and accessibility are critical concerns (Khan & Wei, 2017).

Developing a critical consciousness can be inviting students to question and dispute power relations in the classroom or preparing students to act on social injustices (Morrison et al., 2008). The computing sciences educator can model critical consciousness by stepping in when injustices occur in the classroom. Students can be invited to discuss and take critical perspectives on readings about controversial topics, such as generative artificial intelligence in social media. Altering power dynamics in the classroom is another way to demonstrate critical consciousness. This can be done by reducing the amount of time that the educator lectures to the students and spending more time discussing and doing project-based learning in the classroom. Another way is to allow students to contribute to decisions about policies and assessment such as helping to decide on an appropriate late policy or the relative weight of assessments in the course.

An important way that computing sciences courses can demonstrate critical consciousness is by integrating experiential learning and collaboration with industries that address societal challenges, particularly in marginalized or underserved communities, thereby involving students as active participants in social justice work. When students are exposed to the real-world implications of computing, especially in healthcare or social justice contexts, they are better equipped to understand the broad societal impact of their work and contribute to creating equitable solutions. By listening to these communities' needs, students can then apply their skills to develop technological solutions that directly address the problems faced by underserved populations. This collaborative approach not only enhances students' problem-solving abilities but also fosters empathy and a deeper commitment to creating inclusive and impactful technologies (Khan, 2018).

6. Leadership Commitment and Accountability

Institutional leadership plays a pivotal role in driving sustained diversity efforts. It is critical that leaders not only advocate for diversity but also hold themselves and their organizations accountable for measurable outcomes (Jones, 2024). Establishing diversity metrics, conducting regular reviews of progress, and reporting transparently on challenges and successes create a culture of accountability. Leaders should also support diversity task forces, committees, and dedicated staff who focus on monitoring and improving inclusion efforts.

One key strategy for advancing these goals can be through collaboration with DEI organizations on campus. These partnerships are vital not only for gaining access to students from historically marginalized populations but also for leveraging the resources, events, and programs these organizations

offer. DEI groups often host workshops, speaker series, and networking events that create spaces for engagement and learning. By working closely with these organizations, leaders can amplify their outreach efforts, foster a more inclusive environment, and ensure that diversity initiatives align with the needs and experiences of underrepresented students, achieving a broader and more sustained impact.

7. Collaborative Partnerships and Community Engagement

Sustained impact in diversity initiatives often requires collaboration across sectors (e.g., Peoples et al., 2023). Universities, tech companies, government agencies, and nonprofits must work together to create pathways for historically marginalized populations. Collaborative efforts, such as partnerships with K-12 schools or community organizations, can expand access to computing education and foster a pipeline of diverse talent. Engaging communities outside traditional academic settings also helps to align computing fields with broader societal needs, ensuring that the solutions developed are inclusive and equitable.

Successful efforts to recruit and retain students in computing education and later engagement in computing careers can be enhanced through partnering with K-12 schools. In particular, collaborating with middle schools in ways that help expose students to computing careers and with high schools to provide opportunities for students to crystalize their interests in computing. It also provides opportunities for them to have the prerequisites needed for college-level math, science, and computing coursework, so that diverse students can have access to the computing careers that would otherwise be unavailable to them.

Career education initiatives that involve computer science students meeting with, providing information to, and providing mentorship for middle school students can be highly effective in helping them begin to form a computing professional identity and in setting and pursuing computing career goals (ProjectCSGirls, 2023; Turner et al., 2024). University/high school partnerships that involve high school students in ongoing university research has emerged as a popular option for immersing diverse and underrepresented highschoolers in the world of academic and professional computing in ways that both enhance their current academic pursuits and prepare them for later college coursework and professional development (Lumiere Education, 2024).

Partnering organizations such as Caf éScientifique, a local networking organization that hosts events and programs for local professional communities, can provide students with access to unique opportunities, events, and resources. Caf éScientifique hosts informal discussions and presentations on scientific topics, often featuring leaders in various fields. By attending these events, students can engage with experts, broaden their professional networks, and gain exposure to interdisciplinary approaches to problem-solving. Such collaborations also promote community-based learning, offering students a chance to connect their technical knowledge with local challenges and community needs, ultimately enriching their educational experience and preparing them to be leaders in both their careers and their communities (Khan & Milun, 2021).

8. Continuous Learning and Adaptation

Diversity efforts must remain dynamic to be sustainable. This requires institutions and organizations to engage in continuous learning about best practices, emerging challenges, and evolving understandings of diversity. Regular training on anti-racism, gender equity, and inclusive technologies should be provided to faculty, staff, and students to foster an ongoing culture of inclusion. Moreover, conducting research and assessment of diversity initiatives enables institutions to adapt and refine their strategies over time, responding to new challenges as they arise.

9. Conclusion

Achieving and maintaining diversity in computing is a long-term commitment that requires sustained action, systemic reform, and continuous learning. Leadership should coordinate ways to address structural inequalities by fostering inclusive communities, and thus creating sustainable change. In this way, institutions can create an environment where diverse individuals can thrive. As computing continues to shape the future, ensuring that all voices are represented is not only a matter of fairness but also essential to driving innovation and solving the world's most complex problems. These strategies identified in this paper work together in an integrative manner to support DEI by attending to the needs of

students and the responsibilities of the various stakeholders. DEI work must be dynamic and respond to societal change. Moreover, DEI work impacts and is impacted by both the academic department and the larger academic institution. Thus, aligning institutional priorities and critical initiatives that are adopted across contexts and personnel is requisite for success. Key metrics across groups should be monitored to assess success in meeting the needs of students. Consistent progress across all aspects of DEI work identified here can help to ensure that sustainable efforts to support DEI in higher education computing fields can be attained.

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