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Higher Education Computing Curriculum for the Black Community: A Review

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Abstract

The call to diversify Science, Technology, Engineering, and Math (STEM) fields has continued to echo and grow. While it is common for research to explore these approaches at the K-12 level, the higher education space also contributes significantly in helping to diversify STEM fields through educational approaches. The Black/African-American community is a historically marginalized group that has continued to be underrepresented in STEM fields like computing. Within higher education, the computing education field has used various approaches to target the Black/African-American community through inclusive instruction in classrooms, programming to increase exposure, and even amplifying the voices of those within the field to understand their experiences better. A literature review was conducted to explore what has been done, the approaches used, and how these efforts can strategically contribute to diversifying other STEM fields. The review focused on collegiate level departmental and classroom approaches that target the Black/African-American computing community. The collected existing research in this space was synthesized to understand the landscape thus far and theoretically explored through a cultural lens. The intersection of frameworks such as Culturally Sustaining Pedagogy and Culturally Relevant Computing provides the foundation for the cultural analysis. These frameworks can aid researchers in evaluating approaches for the Black/African-American community and help strengthen the research in this area to culturally connect with Black students in STEM. We explore the use and lack thereof of frameworks related to culture to inform the approaches. This synthesis brings together key literature in this area to provide insight on how to build on approaches to potentially further diversity efforts for the Black community across STEM, particularly by using pedagogical bridges and partnerships.

Introduction

Although there have been years worth of "diversity efforts," the field of computing still struggles.Lack of diversity in computing is documented, according to the US Equal Employment Opportunity Commission African-Americans make up 7.4% of the high-tech industry [1, 2]. The computing workforce is reflective of the computing in higher education stats. According to the 2018 Taulbee Survey, only 5.4% of students enrolled in the responding Computer Science, Computer Engineering, or Information programs identified as Black/African-Americans [3]. Although the statistics look bleak, efforts to change these statistics exist and continue to gain traction. Often called Broadening Participation in Computing (BPC), there have been efforts [4]

to get those who are considered underrepresented in computing involved with computing. Due to the growing computing workforce and noted job growth, there is a tremendous push for BPC. On a national level, the National Science Foundation has established BPC specific research plans and grants to encourage this kind of work[5]. In general, tech companies have also joined in on BPC efforts to get students of all ages interested in computing to increase the diversity of the computing pipeline. Higher education institutions play an essential role in preparing students for the computing workforce. Therefore, addressing diversity at the higher ed level (as students are preparing for the computing workforce) is necessary for growth in the field. As research on educational best practices within the Black community continues to grow [6] and K-12 Broadening Participation in Computing (BPC) projects rise, so should the attention to diversity in the higher education space continue to grow.

Within the United States specifically, there has been a surge in diversity, equity, and inclusion claims by tech companies in response to the racial climate in America [7, 8]. Current events not only bring attention to the plight of Black Americans but also present a good time to look at how the large-scale systemic racism seen in our society is also present in the workforce (specifically tech) and education systems. The systemic racial issues embedded in higher ed and that play a role in the isolation and feeling of otherness that minority groups deal with are important in understanding the statistics around minorities in computing [9–11]. Although BPC efforts are very popular at the K-12 level, higher education is often the precursor to joining the tech workforce and requires attention. So the question becomes, what is the research community doing for Black computing students and what more can we do.

Background

Computer Science Education research has consistently grown over the years. The ACM Special Interest Group on Computer Science Education (SIGCSE) Technical Symposium has been held since 1970. This area of research has explored best practices for teaching programming and computing topics and how to engage with students outside of the classroom. There are numerous critiques and/or criticisms of CS education [12–15]. For example, the Computer Science field struggles with the burden of stereotype threat weighing on its students. Prior research connected the concerns around stereotypes and the lack of a sense of belonging in the field to disengagement among students [15]. Computer Science Education as a research field seeks to explore methods for teaching computer science to students of all ages. However, there is a notable focus on the K-12 level.

Current research on CS Education at the higher education level spans in focus, including topics such as the teaching/instruction of CS concepts (with great emphasis on intro classes), career readiness of students, and industry partnerships. For example, Agbo et al. conducted a systematic review of computational thinking in higher education [16]. Computational thinking (CT) focuses on problem-solving and is used to help teach programming [16]. The authors explore the use of CT in higher ed and how it impacts students learning experiences. Notable findings include the use of CT in a smart learning environment approach which seeks to use a learner-centered approach to enhance learning. The CT approach continues to be beneficial for computing students and shows promise as being helpful to help bridge the gap between freshmen year students that have not had prior programming experience and those that have.

Related Frameworks

In reviewing Culturally Relevant Education in Computing on the K-12 level, Morales-Chicas et al. highlighted themes around the incorporation of culture, raising consciousness, connection to community and experiences, and personalization [17]. Paris suggested the term Culturally Sustaining Pedagogy as a way to encompass the previous work done around Culturally Responsive Teaching (Gay) [18] and Culturally Relevant Pedagogy (Ladson-Billings) [11]while pushing for further recognition of multi-cultural identities. Culturally Sustaining Pedagogy "requires that [educators] support young people in sustaining the cultural and linguistic competence of their communities while simultaneously offering access to dominant cultural competence." [19]. Supporting multiculturalism and viewing identity as an asset are the main ideas from Culturally Sustaining Pedagogy that we hope to bring into computing.

Culturally Responsive Computing (CRC) applies culturally relevant teaching to the design of technology and computing education [20]. Scott, Sheridan, and Clark, added nuance to CRC by proposing the following tenets: (1) All students are capable of digital innovation. (2) The learning context supports transformational use of technology. (3) Learning about one's self along various intersecting sociocultural lines allows for technical innovation. (4) Technology should be a vehicle by which students reflect and demonstrate understanding of their intersectional identities. (5) Barometers for technological success should consider who creates, for whom, and to what ends rather than who endures socially and culturally irrelevant curriculum [14].

These frameworks all begin to help shape the intersection of culture and computing education. Specifically, we focus on ideas such as: supporting students' identities through cultural inclusion, presenting technology as a vehicle for reflection and innovation, and viewing students' experiences as an asset.

Methodology

A systematic review approach was taken to explore the scholarship in this area. The Association for Computing Machinery (ACM) is the largest society for computing; therefore, the ACM digital library was the first database used for the search. In addition to ACM, the researchers searched the IEEE Xplore Digital Library.

The goal of the search was to find research that also intentionally focused on Black people. An emphasis is made on intentionality because often minorities are grouped together under the title of Underrepresented Minorities (URMs), which often includes gender minorities (women, trans, gender non-conforming, etc.) as well as racial minorities [21]. For this review, terms related to the Black community needed to appear in the title or abstract. Following the standards used in US census demographic data, we use the terms "African-American" and "Black" to define the target group. As this survey focuses on higher education specifically, terms related to higher ed, such as "college" or "undergraduate," also needed to appear in the title or abstract. Lastly, we searched for the mention of computing or computing education in keywords and abstracts. Only peer-reviewed work was included.

We selected a total of 36 papers for initial inclusion for the broader research question. During review, those with a general STEM focus without specific mention of computing were excluded.

Then the articles were sorted into the following four categories: Program, Experience, Course Development/Structure and Tools. This paper will focus only on the Course Development/Structure category, which consists of seven papers, and will explore how computing curriculums specifically target the Black community.

Results

All the research reviewed comes from Historically Black Colleges and Universities (HBCUs). Only one paper comes from a journal; the rest are conference papers. The literature spans from 2005 to 2020. The reviewed literature fell into two main categories: Departmental Level and Classroom Interventions. Departmental papers all took an experience report approach, describing the details of creating and the initial results of their interventions. The classroom intervention papers all sought to explore and understand their proposed intervention's impact and/or usefulness. Guided by the frameworks mentioned earlier, the following sub-themes were found.

Departmental - Partnerships for Retention

Washington et al. and Evans & Chatmon both present examples of utilizing outside partnerships to benefit African American computing students [22, 23]. Faculty at Howard University saw the need to debunk common myths around CS, give a better introduction before higher-level programming courses, and connect learning to the real world [22]. The researchers had a singular goal: "to increase the retention of African-American CS undergraduates in the first two years of study." The Googler in Residence (GIR) program was established and placed a Googler at the school as a faculty member. Then Google Computer Science Summer Institute (a Google program designed to teach programming to incoming freshmen) curriculum was combined with the existing CS 0 curriculum to create a new course for first-year students. The GIR program helped students connect to real-world applications of CS and created a connection between the university and Google. Similarly, Florida Agricultural and Mechanical University(FAMU) created an Information Assurance certification program in response to the need for more diversity in the field [23]. Through FAMU's partnership with Florida State University (FSU), they adapted three courses from FSU's curriculum and created an additional two new courses. The courses covered various objectives and the instructional methodology for courses varied. Partnering with FSU allowed the department to not start from scratch while still allowing them to adapt the courses for their students' needs. For both schools, the partnerships help create positive outcomes for the students. Stukes, Chen, and Tidwell also discuss various programming under the categories of Engagement, Capacity, and Continuity (ECC) used at Johnson C Smith University. The work discusses the role industry partnerships played in the Continuity category in helping students complete their degrees [24]. The partnerships particularly aim to help students feel prepared for their careers through mock interviews and support. In these three articles, we see that relevant partnerships benefit faculty and students on the path to increasing interest/retention rates.

Beyond introducing the problems they are trying to solve, the research regarding departmental projects does not take a focus related to the cultural frameworks discussed. These interventions are more extensive, which could contribute to a difference in how the work is examined. The

question then becomes can cultural frameworks inform large-scale departmental interventions. For example, Washington et al. discuss how their program aims to provide networking opportunities; networking support could be a space to empower students to sustain their culture and debunk myths of needing to conform to the majority tech culture by providing a chance to build community and see role models.

Classroom - Pedagogical Bridges

Within classroom work, the motivation seems the same across the board: to improve retention through enjoyment and building interest [25, 26]. When it comes to achieving this, building a pedagogical bridge is a common theme, which directly connects to culturally sustaining practices. Rankin, Thomas, and Irish used food as a pedagogical tool in teaching Computational Algorithmic Thinking to Black women, relating recipes to algorithms, and centering food in the learning modules [26, 27]. James uses Black music as a pedagogical bridge for students in a data structures course [25]. James' course utilizes DJing tasks and Black-music based examples to help students understand various data structures. According to student reflections, the idea of using students' existing "funds of knowledge" to build upon was successful. According to James, students highlighted engagement and an increased sense of usefulness of the material thanks to the music context. Rankin, Thomas Irish noticed a notably higher retention rate using the "Its In the Mix" module versus previous semesters [27]. Specifically, in later work, the "Dessert Wars" challenge from the module proved to provide motivation for African American women [27]. Using students' existing knowledge and experiences (as suggested by Culturally Sustaining Pedagogy) helped these computing students to understand key concepts for success. James also contends that allowing students to choose their own songs was important. Rankin Thomas similarly allowed students to have a choice in which family recipe they use [26]. While the context of both approaches relates to a general theme (food and Black music), we see a need to continue to allow students to make their own connections for relativity and inclusivity; this also supports multiculturalism as seen within *Culturally Sustaining Pedagogy*. Unlike the others in this category, Williams focused on pair programming and collaboration to attract and retain students [28]. They found that incorporating collaboration was engaging for the students. The students appreciated how it showed them that tech is not solitary and provided a more real-world experience. The real-world aspect of the approach could be seen as a way of allowing students to connect the work to their experiences as it debunks the myth of programming being lonely.

Qualitative Evaluation

Among the research, it can be seen that the courses utilize student feedback intentionally to see if the approach is beneficial for Black students. Experiential knowledge, which is also a tenet of Critical Race Theory, plays a large role in the evaluation of students and the course itself [10]. If going the route of attempting to bring in cultural references, student input is important to evaluate the benefit and relevance. There is heavy use of qualitative methods in this research. It seems the research community intentionally chooses not to rely solely on numeric data but also on narrative data to tell the complete story. For example, students were asked to write self-reflections in relation to the Dessert Wars challenge [26]. Having students self-reflect adds another dimension to evaluation, as the students' experience is considered a valid data point for evaluation. This

aligns the research with suggested practices from the cultural frameworks discussed, such as how culturally sustaining pedagogy suggests viewing students' identities as an asset and CRC's suggestion for self-reflection within technological design [14, 19]. Likewise, Williams et al. used interviews as the method for data collection and included long quotes from the participants, which connects to the idea of experiential knowledge in that, again, the student's personal experiences are valid data points [28]. The use of evaluations is important to note because even though courses could center success on pass/fail rates, these researchers seek to understand more about the overall experience with these interventions and the students' self-perceived success.

Discussion

From this work, it is seen that the field could benefit from intentional cultural considerations in the development and evaluation of computing curriculum. This doesn't necessarily have to mean complete course redesign but can involve a reevaluation of examples used, attention to stereotypes being perpetuated, consideration for student comprehension through reflection/input, etc. The major themes seen within this work can also be explored in STEM in general. Bringing culture into the classroom is not solely for humanities courses; STEM plays a major role in our everyday lives, and as such pedagogical bridges to non-dominant cultures should also be considered. Jones Melo argue that Culturally Relevant Pedagogy in Computer Science lacks attention to critical consciousness. Stating that the work seeks to increase the number of marginalized students in the pipeline but that it "does not guarantee more inviting and expansive education systems, careers, or life paths." [12] Attention to the overall systems was not a common theme amongst the reviewed work in this review, but some work does begin to hint at that direction. For example, Rankin, Thomas, and Irish's discussion of equity in the classroom among the students (and even with the instructor relinquishing power to allow students to critique the pedagogical approach) is an interesting segue into a possible discussion of equitable learning environments and what that looks like for these students. The decision to "use self-reflection journals to capture students' perceptions of their learning experiences in their own words to empower their voices to be heard" plays a role in creating a way for students to define success in other ways and gives an example of how researchers can also define success in how the target population describes their experience [27]. As departmental work reviewed called on partnerships, the use of partnerships could also help in creating more inviting spaces and experiences. Those in partnership with the schools could and should also seek to gain deeper insight into the needs of Black computing students. There are limitations with this work, as the search was conducted in 2021. The search terms may have also caused work that is connected to the Black community to be excluded if the delineation was not formally made in the abstract or title. We cannot claim this to be inclusive of all work on this topic; however, it does provide insight into the research area in general.

Conclusion

Literature related to the computing curriculum for the Black community in higher education shows great promise of being beneficial to broadening participation efforts. Within this work, we see how departments can leverage outside entities to build upon existing interventions while making adaptations for more relevance to Black students. Some classroom efforts also pull from educational literature for Black students and merge their identity into the curriculum. There is a

need for and space for allowing Black students to bring their full selves to computing environments and any environment. Using previous work to evaluate higher education through the lens of critical race theory, it is clear how higher education's systemic problems work against Black students [10]. Therefore there is a need to be intentional about interventions to support students and work against the system, particularly on the departmental level, ensuring the overall experience prepares students for the workforce. These few examples of what cultural relevance can look like within a computing course should be just the beginning to exploring adaptions from educational literature into higher ed computing, specifically HBCUs, as it is clear they play a role in this area.

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