# Developing Introductory Computer Science Pedagogy for Black Boys

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***Abstract*— Broadening participation in computing research and initiatives have addressed the longstanding underrepresentation of various populations – including women, Black people, Latinx people, and persons with disabilities. Although there has been an increase in underrepresented populations participating in computing, there is still a need to further investigate and build on these efforts considering there is limited research on the participation of black boys. This position paper discusses the need for an increase in Black male participation in computer science and proposes a framework for developing an introductory computer science curriculum tailored for black middle school boys. This paper will support the proposed framework by identifying factors for how boys learn and the unique needs of black boys in an educational context; then merging those factors with effective strategies used for women and people of color participating in computer science.**

***Keywords—computer science education, culturally relevant pedagogy, broadening participation in computing, intersectionality***

## I. Introduction

When students decide to pursue computer science as a field of study, multiple factors come into play. These factors include enthusiasm towards computing, perceptions of computing ability, community perceptions of computing, resource access, socioeconomic status, classroom climate, pedagogy, meaningful assignments, sexism, and racism [1], [2]. Such factors have been the focus for researchers and educators as they address these issues to help broaden participation in computing [2]. While many initiatives and studies have found success increasing participation in computing for women and racial/ethnic minority groups, few of them focus on black boys.

Most Black people, Latinx people, and women in the United States use mobile apps and computer applications, but rarely do they design and develop these applications themselves [3]. Underrepresented groups account for 16% of the IT workforce [4]. In Silicon Valley, they make up only 5% [4]. Black, Latinx, and women are significantly underrepresented in computing both within degree programs and as compared with their respective percentage in the US population where the population is 13.4% Black, 18.5% Latinx, and 50.8% women [5]. Although computing employment has increased from 2.66 million in 2013 to 2.88 million in 2019, the number of Black and Latinx people and women pursuing computing fields of study is still low as only 18.6% of all CS Bachelor's enrollment were Latinx, Black, or woman [6][7]. On the high school level, the makeup of AP CS Principles is 8% Black, 21% Latinx, and 32% women as compared to 46% White and 68% men [8].

Low participation from underrepresented groups in computing has been known to show negative effects on society [3], [9]. In the United States, more computer science graduates are needed to fill jobs in the growing computing and information technology sector [10]. The employment of computer and information research scientists is projected to grow 15% from 2019 to 2029; much faster than the average for all occupations [10]. One way to help fill these jobs is by increasing the participation rate of underrepresented groups in computing so that it is more reflective of the US population.

Increasing participation in computer science for underrepresented groups will not only help the economy, but also help the respective communities of these groups. Throughout the history of the United States, the black community has been oppressed [11]. Often, black people in the United States are oppressed through the school-to-prison pipeline, where black students are more likely to be disciplined in school and eventually end up in prison [12]. Growth in black people participating in computer science would help mitigate this societal issue by providing job security and increasing access to economic advancement for black families.

In today's society, a digital transformation is occurring, yet individuals of marginalized groups may be restricted in their ability to participate in this movement. Computer scientists create technology that drives society. Some technologies are considered to have algorithmic bias where such systems lead to unfair outcomes or judgments [13]. For example, autonomous cars have been found to misidentify darker-skinned pedestrians 10% more than lighter-skinned pedestrians [14]. Facial recognition technology, increasingly used by law enforcement, is less accurate for black people. These algorithmic errors have real-world consequences as innocent people have been misidentified [13]. To address such issues, we must have a diverse group of people developing such technologies and allowing all groups to have access to participate.

## II. Background

To identify attributes that may be valuable in creating a framework for an introductory computer science curriculum tailored for black boys, I examined papers describing pedagogical approaches for males and minority populations. The papers chosen are not meant to be a comprehensive list, but to provide insight into what is being reported.

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### A. Male Pedagogy

Research has shown that boys learn differently than girls for reasons of both nature and nurture [15]. Starting with the brain, there are differences between boys and girls on how the brain functions and reacts to learning. In the brain, there are chemical differences and hormonal differences that impact learning [15]. Michael Gurian, a pioneer in studying gender learning-style differences, has reported the following key factors differentiating girl-boy learning [16]: (1) Boys' brains tend to display spatial-mechanical strengths, whereas girls generally show a focus on verbal-emotive processing. (2) Girls are generally less impulsive, enabling them to sit still, focus, read, and write at an earlier age than boys. (3) Boys' brains need more rest times during a day of learning. (4) Boys are hardwired to be single-task focused, whereas girls' hardwiring shows strength in multitasking. (5) Less oxytocin in the brain of males leads to more aggression and playful rough-housing; they are movement-driven (kinesthetic) in their learning process. (6) Boys are often misdiagnosed with learning disabilities and attention-deficit disorders when educators are not cognizant of the neurology of male brain development.

Gurian and Stevens have created the Teaching Boys Effectively Logic Model that has helped several schools close gender gaps and raise students' performance [17]. The model consists of the following 10 essential strategies for teaching boys effectively [17]: (1) increased use of graphics, pictures, and storyboards by teachers; (2) inclusion of project-based education that facilitates hands-on, kinesthetic learning; (3) inclusion of competitive learning opportunities; (4) inclusion of skills training in time, homework, and classroom management; (5) approximately 50 percent of reading and writing choices are left up to the students; (6) teachers move around their classrooms as they teach; (7) students are taught how to practice self-discipline in their movement and allowed to move around as needed in the classroom; (8) male mentoring systems permeate the school culture (9) teachers use boys-only group work and discussion groups in core classes; (10) and teachers and counselors provide skill building for sensitive boys.

Hawley and Reichert found that successful lessons for boys fell into the following 8 general categories [18][19]: (1) lessons that produced products; (2) lessons structured as games; (3) lessons requiring vigorous motor activity; (4) lessons requiring boys to assume a role or responsibility for promoting the learning of others; (5) lessons requiring boys to address "open," unsolved problems; (6) lessons that required a combination of teamwork and competition; (7) lessons that focused on boys' personal realization (their masculinity, their values, their present and future social roles); and (8) lessons that introduced dramatic novelties and surprises.

### B. Cultural Pedagogy

#### 1) Culturally Relevant Pedagogy

Ladson-Billings gained insight on how to better teach through her research on low-socioeconomic and mostly African American students by observing eight exceptional teachers [20]. This insight led to the development of culturally relevant pedagogy, a pedagogy that empowers students intellectually, socially, emotionally, and politically by using cultural referents to impart knowledge, skills, and attitudes [21]. Culturally relevant pedagogy must meet the following three criteria [21]: (1) An ability to develop students ***academically***. (2) A willingness to nurture and support ***cultural competence***. (3) The development of a ***sociopolitical or critical consciousness***.

#### 2) Culturally Responsive Teaching

Geneva Gay created Culturally Responsive Teaching (CRT) [22][23][20][24][25][26][27] by building on Gloria Ladson-Billings' Culturally Relevant Pedagogy and similar research that show that academic achievement of ethnically diverse students will improve when they are taught in their own cultural and experiential filter. Culturally responsive teaching (CRT) is the practice of using cultural characteristics, experiences, and perspectives of ethnically diverse students as a channel for teaching them more effectively [22]. Culturally Responsive Teaching has the following six descriptive teacher characteristics [28]: (1) **Validating**: Teachers validate every student's culture, bridging gaps between school and home through diverse instructional approaches and multicultural curricula. (2) **Comprehensive**: Teachers are socially, emotionally, and politically comprehensive as they attempt to educate the whole child. (3) **Multidimensional**: Teachers are multidimensional by engaging cultural knowledge, experiences, contributions, and perspectives. (4) **Empowering**: Teachers are socially and academically empowering by setting high expectations for students and committing to their success. (5) **Transformative**: Teachers are transformative to schools and societies by using students' existing strengths to drive curriculum design, instruction, and assessment. (6) **Emancipatory**: Teachers are emancipatory and liberating from oppressive educational practices and ideologies.

#### 3) Culturally Situated Design Tools & Community

Culturally Situated Design Tools (CSDTs) were created out of Ethnomathematics, the study of mathematical ideas and practices situated in their cultural context, by Dr. Ron Eglash [29]. CSDTs are web-based software applications that allow students to produce simulations of cultural arts using underlying mathematical principles [29]. Examples of CSDTs include Native American beadwork, African American cornrow hairstyles, and urban graffiti. The goal of CSDTs is to address the on-going problem of minority children's below-average academic performance and engagement in math education [30].

Lachney et. al has used culturally responsive computing to repurpose computer science education by making it meaningful to not only students but also their surrounding community [31], [32]. Unlike traditional teachings of computer science, students found this style of teaching meaningful. Implications of this study show that there are innovative ways to support broadening participation in computing for underrepresented groups where educators must engage in life outside the school walls to connect with the community where students live [32].

### C. Computing & STEM Identity Development

Identity has been recognized as a critical issue in the effort to increase underrepresented students' engagement in Computing and STEM fields [33]. Findings from earlier studies indicate that students' doubts about participating are often due

to an unfortunate perception of the discipline, that it lacks personal meaningfulness, which leads to a tendency to dissociate themselves from the computer science field [34], [35].

A sense of fit is prominent during the middle school grades, where students have more autonomy and select what opportunities they participate in. This stage of identity development is critical as many students are concerned with fitting in. This age is also critical because it is when many underrepresented students have taken on an anti-STEM/computing identity that persists indefinitely [36].

The intersection of gender, race, and ethnicity plays a role in the science identity of students. Hazzari et al. found that students' overall self-perception toward science is low [37]. In a survey collecting responses on STEM identities from college students across the United States, Black males had a significantly lower percentage of identifying with STEM fields as compared to White participants [37].

To help African American men better identify with computing, DiSalvo et. al developed Glitch Game Testers, a job training program where they were trained to black-box their game consoles to learn about computing. The results showed participants were more likely to view their peers as technical resources and increased their overall access to technical resources [38]. Also, their results suggested that young African American men play in specific ways that differ from groups who tend to leverage gaming interests into computing interests [39]. African American men value good sportsmanship and place a high value on competition [39].

### *D. Reality Pedagogy*

The message received by underrepresented groups in traditional classrooms is that: to be successful, students must remove themselves from the culture of their surrounding community, conform to expectations of authority, and repress the identities they possess outside the classroom [40]. This type of teaching causes students to lose interest in school and have lower academic performance [40]. To combat this, Emdin proposes reality pedagogy, an approach to teaching and learning that has a primary goal of meeting each student on his or her own cultural turf [41]. The framework for reality pedagogy consisted of the following [41]: (1) **Cogenerative Dialogue**: Conversations between the teachers and students to improve the classroom. (2) **Coteaching**: The transfer of teacher and student roles. (3) **Cosmopolitanism**: Creating a collective sense of responsibility. (4) **Context**: Moving the classroom beyond the school walls. (5) **Content**: Modeling the learning process. (6) **Competition**: Nontraditional demonstration of mastery. (7) **Clean**: Teachers should take an interest in student clothing culture. (8) **Code-Switching**: Students should value their own culture while understanding and appreciating the codes of other cultures. (9) **Curation & Computing**: Allowing students to become curators of their own cultures; the use of computing is one powerful way to do this.

## III. Introductory CS Framework for Black Boys

Research focused on pedagogical approaches that involve male pedagogy, culture, computing/STEM identity, and reality pedagogy has provided theories and supporting evidence that boys and Black students can achieve increased interest, learning, and persistence in computing [16][17][18][19][21][28][29][31][32][38][41]. After analysis of the pedagogical approaches in the Background section, the following themes were discovered to create an introductory CS framework for black boys: cultural; kinesthetic; leadership, agency, and empowerment; competition; media; and mentoring. Within each theme, there are requirements for the following categories of learning: teacher engagement (who teachers are and how they engage students), classroom content (what should the content focus on), and student engagement (what ways can students bring their personal understanding of life into the classroom).

| | Teacher Engagement | Classroom Content | Student Engagement |
|---|---|---|---|
| Cultural | • Teachers are willing to nurture and support cultural competence.<br>• Teachers validate every student's culture, bridging gaps between school and home through diverse instructional approaches and multicultural curricula.<br>• Teachers are socially, emotionally, and politically comprehensive as they attempt to educate the whole child.<br>• Teachers are multidimensional by engaging cultural knowledge, experiences, contributions, and perspectives.<br>• Teachers should take an interest in student clothing culture. | • Course materials and lessons should support connecting students' own culture with learning objectives.<br>• Utilizes Culturally Relevant Pedagogy | • Students should value their own culture while understanding and appreciating the codes of other cultures.<br>• Students bridge the cultural gaps between school and home through diverse instructional approaches and multicultural curricula.<br>• Students express themselves socially, emotionally, and politically.<br>• Students display their cultural knowledge, experiences, contributions, and perspectives.<br>• Students take pride in their clothing culture. |

Table 1. Cultural

Culture is essential to someone's upbringing and understanding of the world that is brought with them to school [23] [28]. The cultural theme (see Table 1) was generated from Ladson-Billings' culturally relevant pedagogy, Gay's culturally responsive teaching, and Emdin's reality pedagogy [23] [28] [41]. They each emphasize the importance of understanding each student's culture and embedding their culture into the classroom.

| | Teacher Engagement | Classroom Content | Student Engagement |
|---|---|---|---|
| Kinesthetic | • Teachers facilitates hands-on, kinesthetic learning.<br>• Teachers move around their classrooms as they teach.<br>Teach students how to practice self-discipline in their movement. | • Classroom methodology includes project-based education with hands-on, kinesthetic learning.<br>• Lessons requiring vigorous motor activity.<br>• Lessons that produce artifacts. | • Students move around as needed in classrooms while understanding self-discipline in their movement.<br>• Students apply previously acquired hands-on skills to education. |

Table 2. Kinesthetic

Research on male pedagogy has shown positive learning effects on boys being engaged with kinesthetic activities [15]. The kinesthetic theme (see Table 2) was created from Gurian's gender learning-style differences, Gurian and Stevens' Teaching Boys Effectively Logic Model, and Hawley and Reichert's successful lesson categories. They discuss boys' spatial-mechanical strengths and need for vigorous motor activities while learning.

| | Teacher Engagement | Classroom Content | Student Engagement |
|---|---|---|---|
| Leadership, Agency, & Empowerment | • Teachers are socially and academically empowered by setting high expectations for students and committing to their success.<br>• Teachers are emancipatory and liberating from oppressive educational practices and ideologies.<br>• Teachers enable co-teaching through the transfer of teacher and student roles.<br>• Teachers are transformative to schools and societies by using students' existing strengths to drive curriculum design, instruction, and assessment.<br>• Teachers structure groups where more experienced students can team up with less experienced students | • Lessons that require boys to address "open," unsolved problems.<br>• Lessons requiring boys to assume a role or responsibility for promoting the learning of others.<br>• Lessons that require teamwork.<br>• Lessons that focused on boys' personal realization in their masculinity, values, present and future social roles.<br>• Use boys-only group work and discussion groups.<br>• Maintain resources, materials, and technology that empowers students to be owners of their learning.<br>• Course materials and lessons encourage having a leader and supporting roles for teamwork activities. | • Students are socially and academically empowering by setting high expectations for themselves and committing to their success.<br>• Students are emancipated and liberated from oppressive educational practices and ideologies.<br>• Students participate in creating a collective sense of responsibility and family.<br>• Students address "open," unsolved problems.<br>• Students assume a role or responsibility for promoting the learning of others.<br>• Students work in teams.<br>• Students have a personal realization in their masculinity, values, present and future social roles.<br>• Students choose approximately 50% content and course material.<br>• More experienced students are willing to teach and/or help less experienced students.<br>• Less experienced students are receptive to learning from experienced peers. |

Table 3. Leadership, Agency, & Empowerment

Leadership, agency, and empowerment increase students' engagement, discipline, and higher academic achievement in the classroom [42]. The leadership, agency, and empowerment theme (see Table 3) was produced from Gay's culturally relevant teaching, Emdin's reality pedagogy, Hawley's successful lessons, and Gurian's Logic Model [28] [41] [19] [17]. They each focus on liberation from traditional and oppressive educational practices, teachers and students sharing power within the classroom, and developing students' sense of responsibility.

| | Teacher Engagement | Classroom Content | Student Engagement |
|---|---|---|---|
| Competition | • Teachers provide competitive learning opportunities, even while holding to cooperative learning frameworks.<br>• Teachers encourage nontraditional demonstration of mastery. | • Lessons structured as games.<br>• Lessons that encourage competition. | • Students place a high value on competition.<br>• Students feel incentivized to demonstrate mastery. |

Table 4. Competition

Competition in learning can promote learning by increasing students' motivation, active learning, adaptivity, and collaboration [43]. The competition theme (see Table 4) was created from Gurian's Logic Model, Emdin's reality pedagogy, Hawley's successful lessons, and DiSalvo's work on Glitch Game Testers [17] [41] [19] [39]. They highlight competitive learning opportunities and games as a vehicle to enhance learning, especially for boys.

| | Teacher Engagement | Classroom Content | Student Engagement |
|---|---|---|---|
| Media | • Teachers increase the use of graphics, pictures, and storyboards in lessons and assignments.<br>• Teachers encourage students to become curators of their own cultures via computing. | • Utilize resources, materials, and technology that leverage media. | • Students express and curate their own cultures using media. |

Table 5. Media

Effective instruction uses media to bridge students' knowledge with the learning objectives of the courses. Media engages students, supports the retention of knowledge, motivates interest in the subject matter, and shows the relevance of many concepts [44]. The media theme (see Table 5) was generated from Gurian's Logic Model and Emdin's reality pedagogy. They discuss the benefits of using multimedia to incorporate students' own culture into learning.

| | Teacher Engagement | Classroom Content | Student Engagement |
|---|---|---|---|
| Community | • Teachers develop sociopolitical or critical consciousness.<br>• Teachers consider co-teaching and developing courses with community members to repurpose computer science education by making it meaningful to not only students and surrounding community members. | • Add context to education by moving the classroom beyond the school walls. | • Students exhibit and develop sociopolitical or critical consciousness.<br>• Students use their existing strengths to drive curriculum design, instruction, and assessment.<br>• Students consider how computing can support their community and its members. |

Table 6. Community

Community-based learning increases students' understanding of their community, businesses, and local needs and issues. Embedding community-based learning into the classroom can enhance connections a students' heritage, foster new ways of learning, and support students' academic interests and knowledge [45]. The community theme (see Table 6) was produced from Ladson-Billings' culturally relevant pedagogy, Gay's culturally relevant teaching, Lachney's generative computing, and Eglash's Culturally Situated Design Tools [21] [28] [29] [38] [39]. They support learning beyond the classroom and within the local community.

| | Teacher Engagement | Classroom Content | Student Engagement |
|---|---|---|---|
| Mentoring | • Teachers establish male mentoring systems (parent-mentors, male teachers, vertical mentoring, and male peer mentoring).<br>• Teachers have conversations with students to improve the classroom. | • Utilize resources, materials, and technology that enables mentoring systems. | • Students take advantage of mentoring system to guide their progression in computing and life.<br>• Students are critical and candid with teachers about how to improve class. |

Table 7. Mentoring

Role models and mentors play a critical role in increasing participation and retaining African American males in STEM fields [46]. Mentoring enables students to envision rewarding careers that they might not have known about or considered. It also provides educational and career advice, encouragement, and support to explore new fields and develop new skills [46] [47]. The mentoring theme (see Table 7) was established from Gurian's Logic Model and Emdin's reality pedagogy [17] [41]. They emphasize the importance of mentoring for boys and minority students.

## IV. Conclusion & Future Work

The Introductory CS Framework for Black Boys is grounded in theory and research in male pedagogy, cultural pedagogy, computing & STEM identity development, and reality pedagogy. From those theoretical and research approaches, the framework was built with the following themes as requirements to benefit learning for black boys: cultural; kinesthetic; leadership, agency, & empowerment, competition, media, community, and mentoring. In the future, I plan to apply this framework to guide creating an introductory CS curriculum for black boys. This curriculum will be used to run future studies to understand its effects on black boys.

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