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Abstract

Science, technology, engineering, and mathematics (STEM) fields face persistent disparities in racial, ethnic and gender representation; these disparities are even more pronounced in computer science (CS) fields where women of color comprise 1 percent or less of all employees. These inequalities, and their causes, are complex, systemic, and result in substantial negative consequences for individuals, organizations, and society. Out-of-school time youth development programs may offer ideal spaces for supporting youth of color in developing computational identities, and thus, improved motivation and aspirations to pursue computer science. We present a theoretical integration of ethnic-racial and computational identity, social justice youth development, culturally relevant pedagogy, and computer science education to advance pedagogical practices to strengthen adolescents computational thinking, ethnic-racial identity, and motivation for continued computer science learning. We hope this approach will help young people build resilience and promote a culture of social justice, to prepare them to navigate the CS industry's predominately White and Asian male culture.

Keywords: *computer science education, ethnic-racial identity, social justice youth development, culturally responsive pedagogy*

Introduction

The United States' economic prosperity and capacity to address complex social, economic, and environmental issues depend on a culturally diverse technological workforce (e.g., National Research Council, 2012). Unfortunately, science, technology, engineering, and mathematic (STEM) fields face persistent disparities in racial, ethnic, and gender representation. White and Asian American males are overrepresented in most STEM fields (Pew Research Center, 2021a; 2021b). In the information technology industry, the workforce is 65 percent male and 83 percent White or Asian, with other people of color facing significant inequities; e.g., Latinx (8 percent), Black (7 percent), or American Indian (0.4 percent) (Equal Employment Opportunity Commission, 2016). Across computer science companies, women of color comprise 1 percent or less of all employees (Evans & Rangarajan, 2017). These disparities result in a less robust workforce, diminished opportunities for product ideation, and bias in algorithm development (Scott et al., 2018). Furthermore, due to the ubiquitousness of technology across public and private sectors, disparities exacerbate wage inequality, most notably for vulnerable communities.

Young people need digital competency and confidence to effectively harness computing power to solve problems and design solutions. Computer science (CS) skills are sought in the job market; thus, helping youth improve their proficiency is important in career preparation (Gallup & Amazon, 2021). Computer science education is strongly related to interest and motivation in pursuing CS in college or as a career (Chen et al., 2023). A core foundation of CS education is strengthening young people's computational thinking, that is, thought processes to formulate problems in a way that may be solved by a computer (Aho, 2012). Computational thinking includes tools and concepts from CS to help people solve problems, design systems, and use computers to their fullest extent in automating intellectual processes (National Resource Council, 2010). Although, all youth need computational thinking abilities, even those who do not plan to go into the high-tech workforce. Helping youth develop computational thinking allows them to become more efficient with technologies and enhance their creativity and innovation (National Research Council, 2010). Computational-thinking skills encourage young people to understand and discover systems in ways that are beneficial to themselves and their communities (i.e., "to create, discover, and make sense of the world, with digital technologies as extensions and reflections of our minds"; Cator et al., 2018 p. 21). While the evidence for the value of learning computational thinking has been emerging for the past decade, it was made more evident during the COVID-19 pandemic, which forced youth to interact with technology in new ways. In addition to operational skills for device usage, learning became more connected to life skills necessary for all students such as critical thinking, problem solving, and self-expression (Mills et al., 2021).

Unfortunately, opportunities for youth to participate in computer science education is limited, particularly for youth in lower-income households, who are Black or Latinx, or who live in rural areas (Gallup & Amazon, 2021). Additionally, there is a disconnect for girls and students of color who often feel they do not belong in the computing community, who do not feel like they can be a computer scientist (Goode, 2010). These digital identity divides include cross gendered and racialized dimensions, and are part of sociohistorical and economic lived experiences, impacting educational and professional pursuits. Youth of color often face stereotype threat in school contexts that take a deficit approach, like focusing on a girl's failure to develop desired identities rather than focusing on the cultural or environmental contexts that make it difficult to do so (Ong et al., 2018).

The causes of these inequitable racial, ethnic, and gender disparities in STEM and CS fields are complex and systemic. Schools face limited access to technology infrastructure and available classes, while teachers encounter tensions to limit "nonessential" subjects due to pressures from standardized testing. Also, schools located in disadvantaged socioeconomic communities often do not have computer equipment available. Youth without access to CS learning are twice as unlikely to pursue CS in college (Gallup & Amazon, 2021). Significant barriers include lower quality educational contexts and "lower levels of family social/cultural and financial capital" (i.e., lower family socioeconomic status, insufficient information about STEM career opportunities) that foster academic success (Bottia et al., 2021, p. 635). Students of color often face cultural barriers including implicit bias, stereotype threat, and microaggressions when learning CS in school, and then in the CS industry, broadly (Bui & Miller, 2016; Rogers et al., 2020). Youth who experience bias and aggression in an out-of-school time program, may begin to understand that things will not change, or that they may not have the agency to assert their discontent, and thus, discontinue participating in programs (Simpkins et al., 2013). Even when people of color persist in CS education, they are hired at lower rates than their White counterparts (Bui & Miller, 2016). Gaining recognition as a computer science person may be more difficult for women of color due to persistent and subtle racism, the supposedly meritocratic culture, and pervasive White male cultural norms (Carlone et al., 2019).

Culturally relevant approaches to STEM and computer science education may help engage culturally diverse populations, particularly youth of color and youth from historically marginalized racial and ethnic groups (Mansour & Wegerif, 2013). In the present manuscript, we present practices designed to engage racially and ethnically diverse adolescent youth in CS education, during the out-of-school time context, emphasizing culturally responsive practices. We acknowledge that culturally responsive pedagogy, focusing only on CS outcomes alone, is not sufficient. Adolescence is a critical moment for influencing future interest and developing one's identity—"Am I a computer scientist?"—and thus, educational interventions must consider salient identity features, and help them build a computational identity (Goode, 2010), as well as awareness of and ability to navigate prevailing cultural values and norms that privilege White men (i.e., White norms—competitiveness, individualistic, and solitary practices—that pervade the STEM and CS workforces; Ong et al., 2017).

We advance practices based on the published theoretical and empirical literature, using analytical literature review techniques (Steward, 2004). The specific literatures include identity development, social justice youth development, and culturally responsive pedagogy (including critical experiential learning). We theorize that the proposed practices will improve young people's motivation and aspirations for sustained study in CS (and STEM more broadly). To create programming for adolescents to thrive and learn computer science in out of school programs, culturally relevant youth development programming needs to include the perspectives of diverse youth cultures and identities, coupled with CS identities. We conclude by sharing practices that integrate CS education with a pedagogical emphasis on positive ethnic-racial identity development through culturally relevant learning experiences.

Identities

The sense of who we are, where we belong, where we *perform* (in various contexts), and how others respond is a core human experience affording and constraining the expression within a cultural milieu (Kroger, 2007; Nakkula & Toshalis, 2013); that is, within the practices, traditions, values, norms, beliefs, routines, and tools adopted, shared, contested, and modified over time by groups of people (Nasir & Hand, 2006; Rogoff, 2003). Since Erickson's (1968) seminal work, researchers have advanced our understanding of identity and how it is shaped. Identity formation is considered a fundamental developmental process that has significant consequences for youth development during adolescence and emerging adulthood. Our focus is on sociocultural influences on identity, that is, the role social interactions have in identity development, exploration, contestation, and renegotiation, as one interacts with various cultural communities.

STEM identity is one's identification to, and relationship with, the fields, disciplines, and practices of science, technology, engineering, and mathematics. STEM identity has consistently shown a link between informal STEM education and young people's sustained persistence in STEM (Maltese et al., 2014; Rahm & Moore, 2016; Tal & Dierking, 2014), although the relative impacts of different experiences are not well understood (Dou et al., 2019). Seeing oneself as someone "who can do and contribute to science" are becoming recognized as important outcome indicators of STEM learning (National Resource Council, 2009). In informal STEM education, the interactions with educators and peers, as well as one's other salient identity characteristics, may serve to shift one's identity toward or away from STEM. Dou et al. (2019) found that students who identified highly with STEM had almost twenty-two times higher odds of intention to pursue a STEM career. Their results also revealed that two categories of experiences predicted STEM identity: (a) talking science, and (b) science media experiences (e.g., books, TV). STEM identity is particularly salient for women of color and Latinas; self-recognition in STEM is reinforced by persistence as well as peer and teacher recognition of them as science people (Carlone & Johnson, 2007; Rodriguez et al., 2019).

Specific to computer science is the development of computational identity; that is, engagement with programming, sense of affiliation with computing or programming, and self-actualization in programming learning (Kong & Wang, 2020). Scholars have framed technology as a tool for identity exploration; we see computational thinking as one method for youth to illustrate or express their identities. The extent to which an individual's computing identity (recognition from friends or teachers, self-efficacy, and interest) influence one's intention to pursue a future computer science and information technology career choice; and found a positive link: "Clearly, the computing identity sub-constructs all strongly predict a CS [Information Technology] career choice" (Mahadeo et al., 2020, p. 7:9). For example, photo elicitation, digital journaling, and digital storytelling have been used to help youth develop a sense of themselves as they share with others (Carter Ching & Wang, 2012). Digital storytelling is a method for youth to explore their identities through "the process of constructing, presenting, and reflecting upon a particular first-person story" (Davis & Weinshenker, 2012 p. 68). Furthermore, emerging empirical evidence suggests CS and robotics-education programs, when they take an asset-based and social justice approach, foster engagement and empowerment, and may help shift marginalized students' affinity for CS (Martinez-Campa & Kier, 2024).

Ethnic-racial identity is one's self-concept, attitudes, beliefs, and affective attachments to social-cultural group membership based on race and ethnicity (Phinney & Ong, 2007; Rivas-Drake et al., 2014a; 2014b; Umaña-Taylor et al., 2014). In the United States, ethnic and racial backgrounds are significant social markers with a checkered past involving discrimination and oppression (Nakkula & Toshalis, 2013). Ethnic-racial identity is a multifaceted, dynamic, and hallmark feature of identity formation during the developmental period of adolescence, particularly for youth whose lives are embedded in contexts in which ethnicity and race are salient (Sellers et al., 1998; Umaña-Taylor et al., 2014). Middle adolescence (typically fourteen to seventeen years old) is a period of heightened ethnic-racial identity exploration (Umaña-Taylor et al., 2014), although positive ethnic-racial identity development does not happen automatically (Gay, 2023). However, ethnic-racial diverse youth exploring their ethnic-racial identity and gaining a sense of clarity regarding this aspect of their identity can serve a protective function and promote positive youth development (Umaña-Taylor et al., 2018). Umaña-Taylor and Updegraff (2007) found that Latinx adolescents who reported higher levels of ethnic-racial identity exploration and sense of clarity were also more likely to report higher levels of self-esteem, which partially mediated adverse effects of perceived discrimination. Development of ethnic-racial identity involves exploration of identity issues and commitment and personal investment in an identity group (Phinney & Ong, 2007)

A focus on youth's computational identity seeks to facilitate and shift how they see themselves in relation to the dominant workforce culture (Markus & Nurius, 1986). The pedagogical emphasis on ethnic-racial identity helps youth confront stereotype threat (i.e., from the predominately White and Asian male CS industry) and explore and reinvent conventional wisdom around STEM education all through affirming kindness and belonging (Estrada et al., 2018).

Social Justice Youth Development

Youth development may be envisioned as a pathway to thriving involving the growth and development in indicators defining a flourishing, healthy young person (Lerner et al., 2010). Youth development programs take an asset-based approach and meet youth where they are, help youth nurture passion (spark), help youth feel like they belong, foster developmental relationships, and cultivate a growth mindset (Arnold, 2018; Arnold & Gagnon, 2019; 2020). The tenants of youth development incorporate physical and emotional safety, developmental relationships, skill building, and opportunities for youth leadership (Lerner, 2004). Youth development has gained widespread acceptance in community-based youth programs as a useful framework to guide the practices of adult practitioners as they structure, design, and evaluate programs (Lerner et al., 2021). However, empirical work in youth development has primarily been conducted in White, middle-class populations and not in culturally diverse groups (Benson et al., 2006; Williams & Deutsch, 2016). Lerner et al. (2021) acknowledge the need for theoretical models, as well as research and evaluation, in youth development with specific racial-ethnic youth populations, with encouragement to "wed ideas about PYD [positive youth development] with a focus on social justice" (p. 1128). Additionally, youth development programs often reduce race and ethnicity into variables, rather than seeking more nuanced perspectives on the complexity of social categories and cultural contexts that shape young people's experiences (Williams & Deutsch, 2016). Furthermore, youth development frameworks do not attend to identity development explicitly (Arnold, 2017); for an exception, see the phenomenological variant of ecological systems theory (Velez & Spencer, 2018).

Despite these limitations, youth development may support adolescent exploration of their pluralistic and dynamic identities through engaging youth in their interests and passions, helping them develop competence and confidence, supporting youth in setting and achieving goals, and providing varying roles to try. Organized youth activities can be settings for cultural socialization providing enculturation (learning about one's own heritage), acculturation (learning about the dominant culture), and assimilation (taking on the cultural practices of the dominant culture) (Iturbide et al., 2019; Ngo, 2017; Riggs et al., 2010).

An extension of youth development may help realize these potentials. Social justice youth development (SJYD) builds on youth development frameworks to focus on identity and youth culture; to strengthen marginalized youth's critical consciousness (Horton & Freire, 1990); to increase youth's understanding of inequitable systems; and to strengthen their capacity to transform these systems through collective action (Ginwright & Cammarota, 2007; Erbstein, 2013). While still an emerging model, SJYD may help empower youth to address issues related to oppression in their community based on any of the protected classes including race, gender, religion, socioeconomic status, or sexual orientation. A study involving Asian youth found that exposure to ethnic racial identity awareness and SJYD reported increased empowerment (Suyemoto et al., 2015). In addition, participants stated they learned about their culture and were better suited to address issues of oppression (Suyemoto et. al. 2015). Practitioners need to support and champion young people in their exploration of their own identities and use understanding to break down barriers of oppression (McDaniel, 2017). Adults involved in SJYD must receive ongoing professional development to best support community activism in youth (Clemons, 2023).

Culturally Responsive Pedagogy

Combined with a focus on identity development through SJYD, programs need to provide experiential and culturally relevant pedagogy to empower, transform, and validate young people's lived experience. Experiential learning is a philosophy and theory of education that centers the role of *experience* in learning (Dewey, 1938; Kolb, 1984). Experiential learning has been commonly adopted by youth development programs to provide *hands-on, mind-on* education (Schmitt-McQuitty & Smith, 2012). Experiential learning is a cyclical process wherein groups have a shared experience, reflect, and then draw abstractions for application in the future (Itin, 1999). An emerging adaptation is *critical experiential learning*, which adds critical pedagogy and political dimensions to the experiential learning cycle (Fields, 2017). Attending to social justice and civil discourse, critical experiential learning helps youth attend to "power, oppression, justice, context, history, and identity to recognize and encourage future action toward the alleviation of oppression in all its forms" (Small & Varker, 2023, p. 88).

Critical experiential learning relies on culturally relevant pedagogy—a model to support young people in sustaining and revitalizing their cultural identities while encouraging them to develop critical perspectives that challenge societal inequalities (Ladson-Billings, 2010; 2021; Gay 2000; 2010; 2023). Culturally relevant pedagogy attends to empowerment, transformation, validation, comprehension, multidimensionality of contexts, and emancipation through development of cultural competence and critical consciousness (Ladson-Billings, 2010; 2021). By helping youth understand that no single version of "truth" is total and permanent (Gay, 2000; 2010; Banks & Banks, 2010), youth begin to understand and challenge the status quo of the current social order (Ladson-Billings, 1995, p. 88). Additionally, young people of color begin to experience an "ethnic awakening" manifested as a "conscious confrontation with their ethnicity" (Gay, 2023, p. 24). This presents an opportunity for youth development programs to provide experiential education to help young people learn about diverse cultural values, heritage, and racial experiences. Effective critical experiential learning helps youth develop the knowledge, skills and values needed to become social critics, reflect on their critique, and make decisions that lead to effective personal, social, political, and economic action (Banks & Banks, 2010). Furthermore, establishing trust, building relationships with diverse families, and actively communicating with them helps in the coconstruction of social norms and program structure (Banks et al., 2023; Simpkins et al, 2017).

Computer Science Education

Computer science education involves engaging young people in foundational concepts of computing and technology involving both hardware and software (coding and programming). Technologies vary and include programming languages (e.g., Scratch, Python), educational robotics (e.g., VEX, Sphero, Lego Mindstorms), microcontrollers (Arduino, Raspberry Pi, micro:bit), as well as foundational and crosscutting concepts like computational thinking.

While computers have been used in education for decades, CS education tends to focus on developing young people's coding (programming) skills, using block-based (e.g., MITs Scratch) or text-based coding (e.g., JavaScript or Python; Durak, 2020; Lee et al., 2022; Weintrip & Wilensky, 2019). Although, core CS concepts are broader and include computing systems, networks and the internet, data and analysis, algorithms, programming, and impacts of computing (see *California's Computer Science Standards;* California Department of Education, 2018). Specific coding concepts include variables, control structures, data types, and syntax. There are other approaches to teaching CS, beyond coding, that include unplugged activities introducing core CS concepts (i.e., group experiential activities), programmable robots (e.g., Yamazaki et al., 2015); designing and coding microcontrollers (i.e., STEM-rich design and coding; Calabrese Barton & Tan, 2018). Regardless of the approach used, guiding principles to teach CS include low floor (easy entry for beginners) and high ceiling (powerful for advanced programmers), including scaffolds to enable transfer, support equity, and is systemic and sustainable (Grover & Pea, 2013; Repenning et al., 2010).

A core theoretical foundation for computer science education is constructionism, which extends Piaget's constructivist learning theory, and attends to social and affective dimensions, and to the design process, use of tools, and production of a shareable artifact (Bennett & Monahan, 2013; Kafai, 2006; Papert, 1993). Resnick (2002) asserts, "our best learning experiences come when we are engaged in designing and creating things, especially things that are meaningful either to us or others around us" (p. 33). The creation of an artifact promotes psychological ownership and motivation, outlets for expression and creativity, and community connection. More recently, constructionism has been extended into design-based learning pedagogical models, (Apedoe & Schunn, 2013; Calabrese Barton & Tan, 2018; 2019; Kolodner et al., 2003), where learners are engaged in identifying needs, gathering data, analyzing information, generating and evaluating solutions, coding prototypes, weighing alternatives, and communicating ideas (Fortus et al., 2004). Design-based learning activities are authentic and build on young people's interests, identities, and backgrounds (National Academies of Sciences, Engineering and Medicine, 2021).

A core component of computer science education is computational thinking, the thought processes used to formulate problems and solutions in a format that can be solved by a combination of humans and computers (e.g., logical thinking and problem-solving). Computational thinking includes decomposition (breaking problems into smaller parts), abstraction (finding patterns and generalizing solutions), algorithm design (including efficiency), and debugging (Shute et al., 2017). Computational thinking has gained recognition as a valuable learning outcome in itself and is a component of the Next Generation Science Standards (NGSS Lead States, 2013). Helping youth learn computational thinking supports them to become more efficient with technologies (in all fields, not just software engineering), enhance their creativity and innovation, shift their identity to seeing themselves as someone who uses computers or becomes a computer scientist, and improve their aspirations to pursue a STEM career (National Research Council, 2010). Computational thinking may be developed through programming/coding and through other subject matter areas and pedagogical techniques (Buitrago et al., 2017).

Proposed Organizational and Pedagogical Practices

Based on the preceding theoretical and empirical literature—identity, culturally responsive pedagogy, social justice youth development, and computer science education—we propose practices that might strengthen young people's ethnic-racial identity and computational thinking concurrently. Our recommendations are also based in the practical wisdom of our own experiences facilitating computer science education to strengthen computational thinking with culturally diverse youth (Worker et al., 2024). Figure 1 summarizes the integration of concepts and anticipated outcomes.

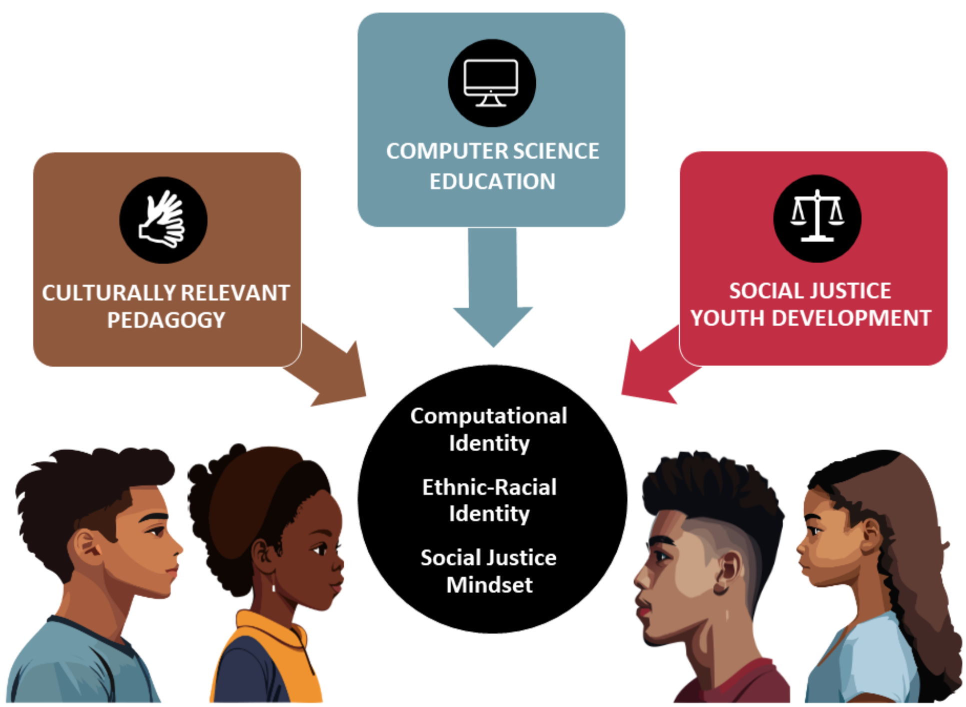

Figure 1. Integration of cultural relevant pedagogy, computer science education, and social justice youth development to strengthen young people's computational identity, ethnic-racial identity, and social justice mindset.

Application to Practice

We offer guidance on strategies for the implementation of these practices to strengthen ethnic-racial identity, computational identity, and a social justice mindset. We acknowledge youth organizations have varying supports, opportunities, and constraints to adopt these recommendations. We organize recommendations into organizational practices for program coordinators and by pedagogical practices for youth development professionals.

Organizational Practices for Program Coordinators and Leaders:

These practices happen at an organizational level by leaders and program coordinators involving the recruitment and preparation of educators before program implementation.

1. *Recruit youth development professionals (educators) that share cultural experiences and identity markers with youth.*

   Adult educators who share cultural history and identity markers with their learners (e.g., Black, Latinx, or women; similar culture or lived experiences) are better prepared to respond to diverse learner needs and interests. The research provides evidence for its value; for example, Black students assigned to at least one Black teacher in elementary school were more likely to graduate high school and attend college (Gershenson et al., 2022). The teacher's ability to connect with students through shared cultural experience was the attributing factor. The study also cited long-term gains when students are paired with teachers that are the same gender and race (i.e., Black female student and Black female teacher). We acknowledge the challenge of recruiting educators who share identity markers and also have two distinct skill sets: (1) CS education, and (2) culturally relevant youth development. Organizations may need to partner educators together, one with experience in facilitating youth development and culturally relevant pedagogy; and another with experience in facilitating CS education. The critical component is ensuring educators—whatever their initial skillset—are committed to self-reflection, becoming familiar with their own and diverse youth cultures; and are committed to providing a safe forum for youth to share, learn, and reflect with each other (Simpkins et al, 2017).

2. *Prepare educators to facilitate culturally relevant youth development (that include social justice) and computer science education using critical experiential learning.*

   To facilitate culturally relevant youth development, educators need to be prepared to: (1) make connections and foster relationships with families, (2) provide multiple opportunities for discussion and reflection (a core component of experiential learning, e.g., individual, pairs, groups) in writing, talking, and other ways of expression, and (3) intentionally introducing students to cultural histories and traditions (Branch, 2020). Furthermore, educators need to recognize and validate preexisting knowledge youth bring to the program, organize collaborative projects with rotating leadership opportunities, and adapt activities to varying literacy levels (Leonard et al., 2018; Scott et al., 2014; Woodley et al., 2017). A sustained, learner-centered professional development approach is essential (Guskey & Yoon, 2009). One such approach is a community of practice, where educators deepen their expertise through sharing and learning from peers on a regular basis (Wenger et al., 2015). Effective professional development helps prepare educators to implement culturally responsive pedagogy. Educators create cultural scaffolding by using their own experiences and demonstrating sensitive caring (Gay, 2023). Research has shown that educators grow their competency after explicit professional development on effective strategies for implementation of culturally relevant pedagogy (Leonard, J et. al., 2019; Scott et. al, 2014).

Pedagogical Practices for Youth Development Professionals:

These practices happen during program implementation typically facilitated by the youth development professional (educator).

3. *Learn about young people's families and cultural history; provide opportunities for parents and families to be involved.*

   Youth development theory has longed advanced the importance of engaging parents and families to help maintain a safe and welcoming environment, ensure appropriate program structure and expectations, and accommodate cultural values and norms (National Research Council and Institute of Medicine, 2002; Simpkins et al., 2017). Involving parents and families in CS education programs has additional challenges. Many adults may have negative perceptions about CS and may lack confidence or competence with their own technology skills (Caspe et al., 2018). However, the importance of engaging parents and families is critical in establishing trust, being culturally responsive, and in supporting young people in exploring their identities (Mapp & Bergman, 2021). Ethnic-racial identity is rooted in cultural heritage, traditions, histories, and values, as juxtaposed with the dominant paradigms, and is greatly influenced by parents and family socialization. Specific strategies youth development professionals may use to sustain family engagement include:

   - Providing welcoming events for parents and families to get to know each other, learn about the program, identify parents' preferred communication channels and levels of CS expertise, and share their familial obligations for schedules.
   - Creating regular communication channels to update families on the program, youth's progress, or logistics.
   - Promoting adult development and offering workshops in response to parents' expressed needs, which may include CS workshops to better support their children's learning.
   - Promoting shared out-of-school time experiences by organizing family-coding events where parents, and participating children, collaboratively work on projects; organizing field trips for the whole family; and including parent's culture and experiences into the curriculum or family volunteer opportunities.
   - Planning exhibit events so youth can share their work and achievements.
   - Engaging parents and family in program governance by seeking their input and collaboration in program planning, implementation, and evaluation (Caspe et al., 2002).

4. *Position computer science education as artistic identity expression.*

   CS and digital technologies may offer unique affordances for youth to explore ethnic-racial identity, inquire and share about the histories, traditions, and customs of their culture. CS learning should be positioned as a vehicle for culturally diverse youth to reflect and express their ethnic-racial identity and culture (as well as reflect on how their identities relate to STEM post-secondary education and careers). Overall, youth will be actively engaged when CS activities are personally authentic and build on young people's interests, identities, and backgrounds (National Academies of Science, Engineering, and Medicine, 2021). We recommend a step-up/spiral approach where youth deepen their understanding of CS and computational thinking concepts through unplugged group experiential activities, programming/coding, and microcontroller design and coding. We suggest lessons incorporate strategies for self-directed programming (e.g., experimenting, planning, persevering, asking for help; Brennan, 2021). The examples of technologies listed below afford opportunities for youth to explore CS artistic identity expression.

- *Unplugged experiential learning*: Unplugged (no computer needed) experiential group activities to introduce one or more computational-thinking concepts, laying the groundwork for programming (Caeli & Yadav, 2020).
- *Block coding*: Introductory computer programming using block-coding (e.g., Scratch) to reinforce the computer science concept, and introduce the digital aspect of coding (Maloney et al., 2010).
- *HTML/CSS/JavaScript*: Three common mark-up and programming languages used for website design, to attend to interactivity, functionality, and accessibility.
- Unity: Software to create two-dimensional and three-dimensional virtual experiences (i.e., gaming or simulation applications that can provide career preparation in technology sectors (Kristiel, 2023).
- *TunePad*: Software that enables users to create, mix, and share music using the Python programming language (Guarino, 2018).
- *Microcontroller coding and design*: STEM-rich design and coding (microcontroller; e.g., micro:bit, Arduino, Raspberry Pi) and project-based learning where youth design, build, code, and test an artifact that involves both code and real-world manipulatives (Calabrese Barton & Tan, 2018).

With these technologies, youth can be engaged in identifying needs, gathering data, analyzing information, generating and evaluating solutions, coding prototypes, weighing alternatives, and communicating ideas (Fortus et al., 2004) to reflect one's ethnic-racial and cultural identity or heritage. This approach is aligned with tenets in constructionism about identity, creation, expression, and community (Kafai, 2006; Papert, 1993).

Research exploring computer programming as an expressive medium (for the development of images, stories, and other artistic messages), while not new, is less well-developed than other STEM disciplines (Maeda, 2001; Steinberg & Gresalfi, 2021). Coding may be an act of empowerment, offering youth a way to tell their stories, reflect on their lived experience, and confront social injustice (Freire, 1970/1996; Ryoo et al., 2020). CS activities may invite youth to exercise agency over creative expression, making choices, defending decisions, debugging code, and receiving feedback from peers. Furthermore, youth benefit from activities that involve collaboration (Garcai et al., 2021). Unplugged activities may be conducted with the entire group or small groups of three to four people. Additionally, coding projects can be completed in pairs, a practice where two youth work together on a single project with designated roles and educator support for effective collaborative work (Barron 2003; Garcia et al., 2021).

5. *Provide role models with similar identities from CS industry.*

Young people need to imagine "possible selves" as computer scientists (Markus & Nurius, 1986); therefore, it is essential CS professionals serve as role models or mentors who share identity markers with participating young people (e.g., race/ethnicity, gender, lived experience, or cultural values) (Driessen, 2015; Lawner et al., 2019). Finding role models is particularly important for CS education, where CS role models have a clear influence on increasing interest in a CS career (Chen et al., 2023). Youth are more likely to thrive when they have caring adults that share common identity markers and make youth and their parents feel more comfortable (Driessen, 2015).

We acknowledge that establishing trust and cultivating industry relationships takes time. Relationship building will assist in finding diverse racial, ethnic and gender role models. We recommend role models share their educational and career trajectory stories with youth participants. Mentorships can "promote positive social identity development"; however, youth-adult relationships may be negatively affected if the role model does not operate through a culturally relevant lens (Smith & Soule, 2016). To support young people's ethnic and racial identity development, ideally role models will also engage in social justice (Branch, 2020). While role models from CS fields are important for youth to develop a strong CS awareness, care must be given to ensure that the adults selected are trained in content and youth development.

Conclusion and Future Work

We propose cultivating young people's computational and ethnic-racial identities concurrently by implementing specific organizational and pedagogical practices based on culturally relevant pedagogies and a social justice youth development approach. We acknowledge that social justice youth development and computer science education have distinct theoretical lineages arising from their own needs and bodies of literature. Bringing them together has been a challenging cognitive exercise and not straightforward, and we acknowledge the need for empirical testing.

In summary, we argue that youth development leaders and professionals need to use culturally responsive approaches to include co-constructing the culture of the program with youth, intentionally placing youth at the center, supporting positive identity development (e.g., having adult role models with shared lived experiences), tailoring lessons to the interests of diverse youth, tapping youth's cultural assets, and engaging families (Erbstein & Fabionar, 2019; Fields & Moncloa, 2022; Simpkins et al., 2017). We assert computer science provides a unique subject matter affordance for adolescent identity exploration, in addition to providing career preparation in a field dominated by White and Asian men. We advance practices that integrates CS education with an emphasis on positive ethnic-racial identity development through culturally relevant learning experiences and a social justice youth development approach. We hope this approach will also help young people build resilience and promote a culture of social justice, to prepare them to navigate the CS industry's White and Asian male culture.

Culturally Responsive Computer Science Education

We offer advice to youth development organizations, based on our experience facilitating CS education with culturally diverse youth. Attempts to retrofit, adapt, or modify existing curriculum, without attending to the dual-complexity involved—computer science and social justice youth development—may not fully engage young people or reach learning outcomes. We encourage youth development organizations to approach improving young people's computational thinking and ethnic-racial identity identities with intentionality and understanding of the resources needed. Ideally, new programs and new curriculum would be developed from the ground up to incorporate *culturally responsive* computer science education, designed to engage marginalized young people's intersectional identities using social justice youth development. We acknowledge that many youth programs face capacity constraints, so at minimum, they need to bring together disciplinary content experts (e.g., computer scientists) with educators who have knowledge and experience with their community's ethnic, racial, and cultural youth and families.

Together, the group of educators should engage in self-reflection of their biases, privilege or disadvantage, and intercultural competence while adapting and implementing programming.

Recommendations for Future Research

We recommend future research to explore how these practices influence young people's positive development, particularly for those racial/ethnic and gender groups underrepresented in CS fields. Build on the emerging literature to study other student's CS identity pathways (e.g., Martinez-Campa & Kier, 2024). Specific questions include:

- How do these pedagogical practices influence young people's ethnic-racial identity, computational identity, and a social justice mindset?
- To what extent do these pedagogical practices increase young people's intention and motivation for continued computer science learning, awareness of, and aspirations to pursue CS post-secondary education and careers?
- Longer term, to what extent do these pedagogical practices influence marginalized group's abilities to be fully represented in CS industries, given cultural issues (e.g., pervasive White male cultural and structural norms)?

We encourage scholars to apply social justice youth development with culturally relevant pedagogy to other STEM disciplines, identifying and leveraging unique affordances to bolster young people's identity and mindset. Youth development programs are well-suited to tap young people's assets and cultural values to raise awareness, strengthen resilience, and help all young people toward a thriving future.

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