

Fore-fronting Relationships: Building Marginalized Students' Computer Science Identities

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With a rise in technology, the demand for computer science (CS) education is increasing in K-12 schools, yet access is inequitable. This research brings together teachers and students participating in a secondary school CS program in the Milwaukee Public School District through an initiative to ensure all students have access to equitable, meaningful, rigorous, and relevant inquiry-based CS education. Utilizing a qualitative approach and grounded theory, this study investigated student-teacher relationships in computer science program participation and what factors from these relationships contribute to marginalized students continuing in an early Science, Technology, Engineering, and Mathematics (STEM) K-12 pathway. Findings suggest teachers served a dynamic role as agents of professional orientation central to how students a) experienced CS learning and b) how students perceived the field they were attempting to enter (development of a CS identity). Moreover, these teachers oriented students into an industry with a history of marginalization.

Keywords: STEM education pathways; high school; computer science identity; marginalized students; student-teacher relationship

Introduction & Literature Review

This research is in coordination with Preparing Urban Milwaukee for Pathways in Computer Science (PUMP-CS), an NSF-funded Research-Practice Partnership that promotes equitable access to high-quality computer science (CS) education for all Wisconsin students in grades K-12. PUMP-CS is a collection of initiatives to ensure that all Milwaukee Public Schools (MPS) students have access to equitable, meaningful, rigorous, and relevant inquiry-based computer science education. The Research-Practice Partnership consists of The Learning Partnership, American Institute for Research, Marquette University, and MPS to assist district leadership in developing healthy student CS identities through clearly defined CS pathways. This partnership works with teachers and school administrators to provide high-quality professional training, curricula, and CS pathways that further develop students' computational thinking as an opportunity to improve educational and life outcomes. The research presented is a continuation of earlier research that explored how students and teachers characterized their instruction and navigation within a newly forming computer science pathway. This earlier research identified four characteristics that we believe are present when students and teachers participate in a healthy CS pathway. These areas are a) Early student opportunities, b) Awareness of Critical Educational Junctures, c) Celebrating, Encouraging Success and Wins, and d) Building Healthy CS Identities (Banwo et al., 2023).

Research on K-12 student-teacher relationships has chiefly examined connections with elementary-

aged populations, mainly because students tend to have closer interactions with teachers when they are younger (Koca, 2016). However, as students age, the value of student-teacher relationships' does not diminish; they change into what Gladstone and Cimpian (2021) identify as a form of mentor, mentee, or role model type process. Gladstone and Cimpian (2021) regard these college and career mentors as serving to model an idea of the future for their students, providing a living example of what it means to be responsible, ethical, engaged, and balanced within the personal and professional spheres of life. Reider et al. (2016) regard these relationships as a part of what they called the "STEM workforce education development," serving to build up the United States' national interest, seeding and growing "homegrown STEM workforces through the development pipeline" (p. 847).

Definition of Mentorship

Our perspectives on mentoring synthesize research focusing on both the mentoring relationship's advising and professional guidance aspects, and how the mentoring relationships develop in healthy reciprocity between the mentee and mentor over time. The latter of which fosters a sense of mutual respect and appreciation (Byars-Winston & Dahlberg, 2019; Montgomery, 2017; Rogoff, 2019). Mentoring "can be defined as a one-to-one learning relationship between an older person and a younger person that is based on modeling behavior and extended dialogue between them" (Lester & Johnson, 1981, p. 50). Jacobi's (1991) review of literature across disciplines, goes on to note three commonalities

among different definitions of mentors and mentees. First, mentoring relationships emphasize helping the individual grow and accomplish goals. We regard this process within the research as a mentor helping a mentee learn a new skill or concept that assists them in their professional journey. Second, a mentoring experience may provide professional and career development support, role modeling, and psychosocial support. We see this process occurring within the “student/teacher care process” that Mayeroff (1971) views as a process of helping another person grow in their “own right.” Moreover, this process of care is not bound up to the interests and well-being of the carer (teacher) but to the one (student) being cared for (Louis et al., 2016). Finally, mentoring experiences should include planned activities with a mentor—something designed by the teacher, not included in the generic curriculum and added materials.

Mentorship and Career Pathways

As our discussion in mentoring also focuses on STEM career choices, we kept the learning theory work of Krumboltz et al. (1976) and Bandura (1977) in mind to develop our perspectives on Social Cognitive Career Theory (SCCT). We also considered identity formation scholarship to explore the experiences of CS identity formation for the students in the study (Goodenow, 1993; Hogg & Adams, 1998; Miller & Desberg, 2009). This literature helped us consider the significance of cultural and racial identity in contributing to marginalized students’ psychosocial wellness. Student-teacher or “mentor-mentee” relationships are critical when preparing minoritized students for hostile environments where they must prove their intelligence and skill. We utilized research about the need for care paid to how program leaders engage notions of race, ethnicity, and gender, particularly how these leaders encourage marginalized students to enter fields of study that will put them at risk of isolation (Herrera et al., 2012; Sims, 2018).

Methodology

This qualitative study investigated the factors of student-teacher relationships in CS program participation that contribute to marginalized

students continuing in an early CS pathway. This research is a part of the PUMP-CS Project, an ongoing long-term Research-Practice Partnership (RPP) that seeks to promote equitable access to high-quality Computer Science (CS) education for all students in Wisconsin across grades K-12. Four pairs of teachers and students participating in the CS pathway participated in the study (Table 1). Researchers examined K-12 teachers’ and students’ relationships within the context of CS as social, professional, and orientation bonding processes between mentors and mentees. Researchers used a descriptive qualitative design based on grounded theory (Glaser & Strauss, 1967). Data was derived from semi-structured interviews (Weiss, 1995). All interviews were recorded using Zoom Video Communications due to the Milwaukee Public Schools COVID-19 closure. Automatic Sync Transcription services and the lead author performed interview transcription. The interviews lasted for an average of 30- 45 minutes. The first author also conducted two impromptu meetings with MPS teachers after classroom visits. These meetings lasted 20- 25 minutes and were conducted using Zoom Video Communication.

Following each interview, field notes were taken. These included brief data on the participants interviewed and observations made during the interview or classroom. Interviews were analyzed and categorized according to the constant comparative method of data analysis (Corbin & Strauss, 2008). Themes in the data were found using open coding; Lester & Johnson (1981) and Jacobi (1991) were used to define, clarify, and make meaning about the areas of mentorship through axial and selective coding (Saldaña, 2009). All names used are pseudonyms.

Findings

Earlier research conducted in Milwaukee that looked at the characteristics of a healthy educational pathway found four components present when students enter and continue long-term CS programmatic participation: Early Engagement; Critical Junctures identified as areas of school building traffic, racial and gendered criticality; Celebrating Wins; and Identity Building (Banwo et al., 2023). Moreover, students’ requests for help depended on their background, particularly during their early years of CS

Table 1
Student and Teacher Participants

Student	Student Ethnicity and Gender	Corresponding Teacher	Teacher Ethnicity and Gender	Grade
Peter	Asian (Hmong), Male	Mrs. Nickles	Euro American, Female	10th
Mark	African American, Male	Mr. Dawson	African American, Male	11th
Mary	African American, Female	Mrs. Torres	Latina, Female	9th
Abigail	Latina, Female	Mrs. Torres	Latina, Female	9th

participation. Like earlier findings, the present research found that students' view of their mentor (teacher) turned on the desired need for help. From this research, for example, the two young women of the study were encouraged and pushed into the CS pathway by extrinsic values (their mentor and teacher). In contrast, the young men relied on their intrinsic values (families and hands-on experience repairing electronic devices, and a caring person helping them to see themselves as a part of the CS community) to serve as a driver into a CS pathway as an opportunity to expand their interest in electronics repair.

The following findings, categorized into three mentorship commonalities identified by Jacobi (1991), underscore the transformative power of the curriculum and relationships in shaping a unique student-teacher mentor and mentee process. This process can potentially transcend traditional student-teacher relationships, evolving into a form of mentorship that can profoundly impact students. Through these sections, we aim to illustrate how teachers' support, instruction, and encouragement can create a learning environment that fosters not just academic growth but also personal and professional development.

Area 1: Growth Through Mentoring Relationships (Emphasize helping the individual grow and accomplish goals)

Mrs. Nickles and Peter are our most incongruous pair of mentors and mentees in the study. Peter is an 11th-grade Hmong student who worked with his father in a small electronic repair business before participating in CS programming in the 7th grade. Peter identified that his interest in the CS field began with his love of Japanese anime, which he hopes to become involved in as a career. Mrs. Nickles, Peter's CS teacher, entered the district as a bilingual language teacher but taught in the social studies and science content areas because of MPS' teacher shortage. MPS began contacting teachers to implement STEM programming as a cross-curricular project focused on helping students enter the computer science field as a possible career option. Mrs. Nickles, who described herself as an "energetic first-year teacher," viewed this initiative as an excellent option to help her students find appropriate post-K-12 opportunities.

During her interview, Mrs. Nickles spoke about how she structured her computer science course to empower students, particularly women, to engage their futures through skills-building (CS training) and computational thinking. For her, CS programming is a tool that supports students' acquisition of technical and social skills. This acquisition of resources is a part of the student socialization process that works to build the mentee's professional toolbox. An example of this pedagogical approach was Mrs. Nickles' promotion of social and community understanding through cross-content CS work; for example, when her school was reading the book *The Hate You Give*

in English classes, she used the theme of the book during her HTML unit by having her students create web pages that shared the theme of the book:

So, in my class, we were doing our HTML unit, so they created webpages that shared the theme of the book and how it connects to our lives, and then kind of brought in like a community piece...I think there are real-life connections that are really important in their education. And I think that computer science is a great way to make those connections plain and see the value in their other classes because computer science is so easily inserted into any other content area.

Mrs. Nickles saw her role as getting students ready for the next level and helping them understand how CS programming and knowledge could be helpful in many areas of life, stating, "You can see how we went from Hate You Give to talking to students about games and things like race... it's all connected." We see her enacting care practices that a) help students academically, but also b) help students connect their CS professional training to other areas in their lives. It is how she describes it "all connected."

Area 2: Professional and Career Development (A mentoring experience that provides support, role modeling, and psychosocial support)

Mark and Mr. Dawson, the second of our student-teacher pairs we would like to highlight, are acting out the relationship pattern mentioned in the sub-heading, particularly through a shared cultural and racial understanding. Mr. Dawson is a Black male and former technology professional who is intimately aware and knowledgeable of the sector and field Mark is entering. During his interview, Mr. Dawson spoke about how his teaching went beyond just training students in the computer sciences but also introduced students like Mark to the social aspects of the technology field.

For example, during his interview, Mr. Dawson spoke about his interest in the experiences of minoritized male students; he found many of his best male CS pupils were students he called "lone wolves," or students he describes as being able to filter out the noise of society of "what a Black kid is supposed to be and focus on the future." This lone wolf status troubled Mr. Dawson because he felt these young men believed they needed to disconnect from their community in order to succeed, stating:

I tell them not to work on their own but to find ways they can talk to somebody else who may help them. It may feel as if it's downgrading, but it's really an upgrade if you ask somebody else for help. And so, having that opportunity to tell the kids, "Hey, don't limit yourself, ask somebody, ask for help because you can't do

this all alone.”

Cole III (2019), in his work with K-12 Black male students, found that this “lone wolf” phenomenon was somewhat a part of the culture of Black males who had the drive and ambition to push through social phenomena like undereducation, racism, and stereotyping. While Mr. Dawson’s concern about his “lone wolf” students could be classified as care, it is also a cultural nuance that Mr. Dawson, a Black male, has a unique cultural window. We found Mr. Dawson and other teachers creating a process of intentional and direct acknowledgment of race and gender akin to a personal mantra that helped them identify students who could have failed to enter a CS pathway. These deliberate and direct conversations served as guides to students through what they regard as a career field that will have detours to career success and advancement based solely on their racial identity and gender. In a sense, these teachers display a form of mentorship by onboarding the students into the CS career field with their racial and gendered identities intact and centered.

Area 3: Intentional Mentorship Activities (Mentoring experiences should include planned activities with a mentor)

Mrs. Torres, the third and final mentor we are presenting, plays a crucial role in fostering confidence among two young women, Mary and Abigail, thereby encouraging them into a CS pathway. A significant issue in research about women and STEM training is their perceived lack of confidence in performing tasks (Liberatore & Wagner, 2020). In our study, the young men (Mark and Peter) demonstrated self-assurance when discussing their CS abilities and knowledge, while the young women (Mary and Abigail) used language indicating unsureness. For instance, when Mary spoke about her first computer course, she expressed.

Honestly, this year, when I took computer science ... I wasn’t really a computer person, but I don’t know; this this just opened up, like, a lot of different aspects of me to look at... It was fun, so I just liked it. So I don’t know.

During her interview, she spoke about being afraid and waiting until her school mandated a STEM class until she decided to enter a CS program. Mrs. Torres described her approach as building “young women’s confidence” and ensuring they see themselves as equally deserving to be in the room. Indeed, Mrs. Torres created activities and situations that encouraged inclusion, which helped the young women begin to see themselves within the CS classroom. According to Mary, Mrs. Torres went above and beyond her duties to ensure her success, such as giving her extra time and attention and structuring her classroom in a way that celebrated wins and achievements, boosting

students’ confidence. This transformation in Mary’s attitude towards CS education under Mrs. Torres’ mentorship is a powerful testament to the positive impact of mentorship on young women’s confidence and participation.

Another example is Abigail and her early experiences with Mrs. Torres in the 7th grade and then having her again in the 10th grade, when Mrs. Torres moved from middle school to high school. Like Mary, Mrs. Torres was focused on how Abigail was experiencing the classroom. Abigail reported that there would be days when she was tired or irritated from home life issues, and Mrs. Torres would take her time with her and develop ways to keep the class fun and engaged. However, Abigail remembered how Mrs. Torres would structure the class to encourage them to talk and engage with each other. Mrs. Torres said this intentional pedagogical approach was to help the young women see that the course wasn’t just “the boys’ club.”

Discussion & Conclusion

Social understanding of care and identity goes much deeper than this slice of research; our purpose for this work was to support practitioners and researchers in understanding why students enter, persist, and succeed in CS pathways. Estrada et al.’s (2018) research on mentor-protégé dynamics shows how mentorship description involves care and intentional identity acknowledgment. Estrada et al. see that mentorship happens best when there are the following elements: (1) Instrumental support provided resources and opportunities for the protégé to engage in goal attainment (Kram, 1985); (2) Psychosocial support; and (3) Relationship satisfaction which may include feelings of trust, empathy, respect, and connectedness.

Each participant pair had a mentor-mentee relationship story that informed the student’s entrance into an educational pathway. Although this research stemmed from a more extensive study (Banwo et al., 2024), we find that examining the student-teacher relationship deepens our understanding of teachers’ effects on students’ CS identities.

As we close, we would like to highlight potential areas where teachers may unintentionally overlook or misunderstand the unique needs and experiences of their students due to cultural or gender differences, when teachers are enacting mentorship relationships across cultures and gender. Although our study featured a combination of different genders and ethnicities, the most common pairing in majority-minority districts (white females and students from marginalized communities) raised concern that there was a misunderstanding in which the teacher failed to account for the socialization experience of male students from marginalized communities (Henfield & Washington, 2012).

Examining the CS experiences of Abigail, Mark, Mary, and Peter, we witness a profound

transformation. For Mark and Peter, their intrinsic interests, such as fixing electronics and being interested in animation, were not just hobbies but the seeds of their future. For Mary and Abigail, the positive support from Ms. Torres was transformational. From our earlier research, we believe this shift was a combination of mentorship, encouragement, celebrating success, and simply students being in the right place at the right time (i.e., luck). However, it is the teacher-student mentor-mentee relationships that are the catalysts in encouraging students to enter CS pathways. Our teachers have tirelessly advocated for their mentee's CS identity development and successful matriculation into adulthood. As Louis et al. (2016) described, caring is a process of helping another person grow in his or her "own right." In the CS field, we must remember that the care process should not be bound up in the caregiver's interests and well-being but in the persons receiving the care—which is how we have come to understand teachers' and mentees' relationships in our study.

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