

## Article

# Building Bridges in STEM Education: Minoritized Secondary School Student Computer Science Pathways and Experiences

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**Abstract:** The experiences of underrepresented women and ethnic minorities in computer science (CS) fields are at the heart of understanding the factors that impact the critical transitions students face when entering into Science, Technology, Engineering, or Mathematics (STEM) careers. The research, conducted using a grounded theory approach, gauges student and teacher perspectives, specifically investigating minoritized student perspectives that influence their entrance and continuation into an educational pathway. The study's outcomes underscore the crucial roles of (1) Student Family Encouragement, (2) School and Community Engagement, and (3) Professional/Teacher Mentorship as critical junctions that school districts should be aware of when creating student pathways into college and career, particularly for underrepresented groups.

**Keywords:** STEM education; STEM pathways; computer science; historically marginalized; underserved students; middle school; high school; critical transitions; mentorship; STEM identity



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## 1. Introduction

For some time now, there has been a concern that the United States does not produce sufficient numbers of students or workers trained in computer science (CS) fields to remain globally competitive [1]. Of particular concern is the underrepresentation of women and ethnic minorities in Science, Technology, Engineering, or Mathematics (STEM) fields. For example, African Americans and Latine made up around 27% of the overall United States workforce as of 2016; however, these two groups account for only 16% of those employed in a STEM occupation [2]. When considering why this underrepresentation continues, past research has suggested that the field needs to pay greater attention to how Black and Latine workers are seeded and grown into STEM or, most importantly, computer science professions [3]. Indeed, for many watchers of the fields inside STEM, this underrepresentation of women and minorities serves to fortify our society's opinion and imagination of what or who a scientist is. Moreover, these patterns of undisrupted negative views run the risk of reinforcing processes that fail to “tease out” ethnic minorities and women's experiences within the larger STEM field [4].

Understanding why minoritized students enter into computer science pathways is imperative for researchers and educators interested in opening up the world of computational thinking as a new and innovative learning mode. Though many computer science groups, program operators, and agencies see the potential of computer science pathways to guide underrepresented students into computer science careers, we regard these pathways as new and needing further examination. In this study, we thus explore four high school students' experience with computer science pathways in the Milwaukee Public School system. To this end, we asked the following research questions:

- (a) How do current high school students participating in computer science programming understand the connection between their computer science identity and participation in an educational pathway?
- (b) Does early CS participation and teacher support create a “student perception” of a CS pathway (i.e., self-perception of continued CS participation on the next level) to computer science participation in college and beyond?

The students speak about how their desires, fears, and family (families for this article are defined to include biological parents, stepparents, and adoptive parents. This includes anyone serving in place of a biological parent, such as other family members (e.g., grandparents, aunts, uncles, siblings, and cousins), guardians, foster parents, or court-appointed surrogate parents. For some, the extended family may comprise neighbors, clergy, community leaders, or anyone actively involved in caring for the child.), and dreams all affected how they arrived at their computer science program and their burgeoning computer scientist identity. Moreover, this research yielded a new framework categorized by three characteristics, (1) Student Family Encouragement, (2) School and Community Engagement, and (3) Professional/Teacher Mentorship, which informs how students enter educational pathways. We hope this new framework will supplement researchers’ and practitioners’ ideas of what a healthy educational pathway consists of.

### 1.1. Computer Science Identity Development

Hogg and Abrams [5] regard social identity theory as the idea that a person is knowingly aware that he or she belongs to a social category or group. A social group comprises individuals who hold a common social identification and view themselves as members of the same social grouping. Indeed, in “A Social Comparison Process”, persons who are similar to “the self” are categorized with the self and are labeled the in-group; persons who differ from the self are categorized as the out-group [6]. Thus, Hogg and Abrams [5] theorize that there are two critical processes involved in social identity formation, (1) self-categorization and (2) social comparison, with both serving as design mechanisms, complicating and guiding a person’s identity down twin paths of conformity and uniqueness.

For this article, we define a healthy STEM identity as 1. persons who think of themselves as science learners and those who 2. develop an identity as someone who (a) knows about, (b) uses, and (c) sometimes contributes to the field of science [7]. We hypothesize that building CS identities will work in the same way. This study aims to fill a gap in knowledge within the CS field as “further research is needed to dig deeper into the nuances of CS identity and engagement” [8] (p. 8). Research suggests a series of structural, familial, normative, and K-12 educational experiences that are necessary to support student computer science identity development [9].

### 1.2. US Computer Science Secondary School Pathways

The K-12 Computer Science Framework [10], a first of its kind in the CS education domain, describes computational thinking as the thought processes involved in solving problems, particularly problems that can be expressed as steps or algorithms that a computer can carry out. For us, educators’ embrace of computational thinking models serves as an opportunity to realign the K-12 mission (i.e., Knowledge and Social Preparedness) to better meet the needs of our information-age society. Indeed, this focus on a step-by-step praxis equips students with problem-solving skills that allow them to analyze, make inferences, and break problems down into manageable pieces [11]. In addition, the National Association of Colleges and Employers Job Outlook 2020 survey found that beyond a strong GPA, problem-solving skills and the ability to work as part of a team are the most crucial attributes employers seek when organizing their workplaces [12]. Taking the notion of student preparedness (i.e., socialization) seriously requires K-12 school districts to think about how they can devise systems and curriculums that serve their students for their future.

The US does not have a national curriculum; instead, individual states adopt their standards for content areas. State departments of education develop content area stan-

dards and can choose to what degree national standards, generally created by volunteer organizations, influence or guide their standards development. Adopting state content area standards is often followed by developing a statewide assessment system to gauge progress across school districts in achieving these standards, in accordance with federal requirements for annual statewide tests. State education agencies vary in how they support curricular resources for school districts to implement. Some adopt statewide curricula informed by state-adopted standards and others do not regulate this at the state level, giving local school districts control over their curriculum.

Science and mathematics, STEM disciplines, have a long history of infrastructure at the national and state levels in developing standards and assessments [13]. This institutional support at the national and state levels has led to all states requiring multiple math and science credits in secondary schools, considered core admission requirements for higher education. Computer science has seen an expansion in the last decade and a recent analysis of state policy indicates that most states are either developing CS standards or have adopted them [14]. Although the majority of states have adopted CS standards, only nine states require high schools to offer CS, eight states and one large urban district [15] require students to take CS to earn a high school diploma, and three states require elementary or middle schools and high schools to offer CS [16]. In 2018, a longitudinal national survey supported by the National Science Foundation conducted its sixth iteration: the National Survey of Science and Mathematics Education (NSSME) [17]. It included computer science for the first time. Unlike science and mathematics, the results show that computer instruction is offered at only some schools with female students and that students from historically underrepresented groups make up little of the computer science course enrollment [18].

### *1.3. Factors Contributing to Computer Science Participation and Identity Development*

#### *1.3.1. Race, Ethnicity, and Gender*

For many STEM and social science experts, the underrepresentation of minoritized groups and women also serves as an economic obstacle to social improvement within the larger society. Funk and Parker [19] found that the representation of women, African Americans, and Hispanics (The term “Hispanic” is used only when directly referencing other sources. Latina/o/e/x refers to the mosaic of Latin American cultures and identities.) hold economic issues or, as they termed it, “pocketbook implications for workers”. In many cases, STEM jobs and careers have relatively higher incomes and flexibility than many non-STEM jobs and denying access to these career paths places these underrepresented groups at a significant economic disadvantage. Moreover, Funk and Parker [19] also noted that “One potential barrier for those wishing to enter the STEM workforce is the generally higher level of educational attainment required for such positions. Among college-educated workers, one-in-three (33%) majored in a STEM field [2] (p. 17)”. The under-representation of women and minoritized groups in more lucrative engineering and computer science fields significantly adds to the widening earnings disparity that has expanded over the last decade [2].

However, when looking at how students acquire a “Scientific Identity”, Herrera et al. [20] theorized that it occurs in a person’s social adjustments and negotiations, similar to how Hogg and Adams [5], describe traditional identity formation. Studying the relationship between a STEM identity and other psychosocial identities such as race, gender, and ethnicity shows that students redefine what it means to be a scientist and a person of color within a social group [20]. Researchers also found that marginalized populations need care paid to how program leaders engage notions of race, ethnicity, and gender, particularly with regard to how these leaders encourage students to enter fields of study that will put them at risk of being isolated [20].

The significance of cultural and racial identity contributing to marginalized students’ psychosocial wellness has been well-documented and studied in the Social Science and Education literature. Using a case study methodological approach, Lane [21] found that, while STEM classes were hostile environments in which Black students felt they needed to

prove their intelligence, intentionally designed undergraduate research programs provided a space in which they “could fully realize their intellectual selves as Black individuals [16] (p. 165)”. The level of identity activated (the personal or the social) depends on factors and situations. Thus, clearly and intentionally building programs that understand how and what moves students in a positive direction will help the field grapple with and improve how identity and marginalization could combine to build better pathways for underrepresented groups.

### 1.3.2. Significant Others

A relational aspect of identity is also connected to how students are guided into the field. Research studies have shown that support from peers, community members, family members, and professional educators helps students develop a greater sense of identification and persistence within the computer science field. Jacob et al. [22] found family, both immediate and extended, to be a cornerstone of Latinas in elementary school attaining strong CS identities in a yearlong study exploring shifts in students’ identity trajectories. On the other end of the education spectrum, in a qualitative meta-synthesis examining empirical research over 20 years on minoritized women in computing and tech graduate programs within institutes of higher education, Jaumot-Pascual et al. [23] often found that success and persistence came from key social actors both inside and outside of the education institution such as community members, peer groups, K-12 teachers, advisors, mentors, and families. Some, like Estrada, Hernandez, and Schultz [24], regard professional guidance as a form of mentor–protégé understanding that they see in three crucial factors for mentees experiencing positive outcomes [25].

- i. “First, mentors can provide instrumental support, provided resources and opportunity to the protégé to engage in goal attainment [26], which can include ‘the specific mentor behaviors of providing task-related assistance, sponsorship, exposure and visibility, and coaching’” [19] (p. 3);
- ii. Second, psychosocial support occurs when a mentor enhances “an individual’s sense of competence, identity, and effectiveness in a professional role” [27] (p. 3);
- iii. Thirdly, relationship quality (sometimes referred to as “relationship satisfaction”) is an adequate assessment of liking and may include feelings of trust, empathy, respect, and connectedness [27] (p. 3).

## 1.4. Organizational Factors Fostering Computer Science Participation and Identity

### 1.4.1. Authentic Learning Experiences

For minority–majority K-12 school districts and especially those in states with no CS state plan, student pathways into fields like computer science require strategic thinking and planning if we are to see improvements in the number of underrepresented persons in STEM fields. Scholars, like Sims [28], believe that districts need to build out curriculums and practices that embrace their minoritized communities’ uniqueness (Sims, 2018). Indeed, Sims built upon the notion of “expectancy-value-cost” that seeks to understand why and how marginalized male students fail to develop an interest and desire to enter fields defined by computational thinking. Based on the research of Eccles et al. [29] pertaining to students’ choice of majors and careers, much of these choices depend on how much value students put in the field and their expectations that they will be successful. Eccles’ research has shown that students’ expectations of success are based on successful experiences with relevant school subjects over time. Students’ value in a particular field is influenced by their enjoyment of experiences in the field.

In a recent NASEM [2] consensus study report investigating the role of authentic learning experiences in developing interest and competencies for computing, a national committee interrogated authenticity from both the perspective of authenticity to the profession and from the perspective of authenticity to the learner [2]. The study concluded that “programs and learning experiences stressing professional authenticity may be uninteresting and unwelcoming in the eyes of learners from groups underrepresented in STEM” [3]

(p. 5). However, the programs stressing professional authenticity did increase the skills and competencies used in computing professions compared to programs more focused on personal authenticity, so designing CS learning experiences should reflect the interests and cultures of particularly underrepresented groups described, personal authenticity, and authenticity to the profession. Both forms of authenticity should not contradict each other and learning experiences should embody both forms of authenticity to broaden the participation of groups historically underserved in CS [2]. With this knowledge, minority-majority districts interested in creating pathways for underrepresented persons in STEM fields must consider how opportunities forecast their students' futures and opinions of STEM and its offshoots.

#### 1.4.2. Early Computer Science Opportunities

Although our quest for social justice in the United States is a long and winding road, onlookers of the STEM field, particularly within the area of computer science, find practices like early and intentional programming with minoritized groups and women as green shoots to progress [10]. Early opportunities from groups such as, "K-12 Computer Science Framework; Computing Machinery; Code.org; Computer Science Teachers Association; and Cyber Innovation Center" function as opportunities to begin shaping and cultivating a positive computer science identity. For example, Code.org's theory of change is their belief in building a "full K-12 curriculum pathway" [14] as an opportunity to address diversity in K-12 computer science that ultimately serves to diversify the technology sector [30]. Similarly, programs like Exploring Computer Science (ECS) also consider their intentional focus on youth as an opportunity to build positive attitudes toward the technology sector within underrepresented populations [31].

Many of the short-term outreach opportunities used in districts before the systematic introduction of intentional CS pathways were intended to raise young students' awareness of the computer science field [32]. Indeed, for Abu-El-Haija and Payton [33], these opportunities typically target K-12 students as a mechanism to encourage them into CS career paths. However, as CS careers and culture have become more prevalent within our society, programming in primary and secondary schools has become more sophisticated and focused on concepts and practices from computational fields.

Studies have begun to unpack how early and continuous CS programs create pathways that orient students into the computer science field. Abu-El-Haija and Payton [33] describe these pathways as an opportunity to address the ethnic and gender disparities in the computer science field by highlighting the inequities in the field and crafting curricula that challenge its historical narratives of lack of interest. Brady et al. [34], when examining the program growth of Computational Thinking for Girls (CT4G), found that the growth in enrollment in the CT4G workshop was in conjunction with attitudinal gains, which suggests the power of providing multiple pathways into computing. Researchers also found that the more the program was "made real or put into the student's social context", the better students began to understand what it would mean to be a computer scientist, which led to better-prepared students, and, most critically, a better-prepared student mindset and imagination ready to tackle their computational futures [4].

#### 1.4.3. Structured Pathway Programming

Carlone and Johnson [35] maintained that students in structured STEM programs could engage in collaborative environments that allow for opportunities to be recognized by peers and faculty, which, in turn, allows them to identify as scientists. This key finding undergirds the importance of early and intentional CS pathways as an opportunity to build a love and interest in a CS future within students. For example, Oseguera et al. [36], studying Hunter et al. [37], "found that summer undergraduate involvement had shifted students' attitudes to 'becoming a scientist' which made them more mindful of their role and engendered a sense of ownership toward the work they were engaged in" (p. 232).



Moreover, Carlone and Johnson [35] found that being a part of a structured program connected to the STEM fields brings individuals with similar interests together, facilitating their identification with a scientific identity. For example, Espinosa [38] found in her study of “Pipelines and Pathways” that minoritized students who consider science a vital aspect of their self-identity are more likely to persist in their STEM major. Conversely, scholars have asserted that students who are recognized by faculty as are “science people” and (1) more confident about their academic abilities, which (2) serves as a predictor of students remaining in STEM fields after their formal education period [39].

### 1.5. Project Partnership and Background

The study was conducted in Wisconsin, a midwestern state of the United States. Wisconsin has adopted state CS standards but does not have a state plan to articulate the implementation of these standards. It also does not have a CS graduation requirement for all high school students [16]. In total, 56% of high school students in Wisconsin have access to foundational computer science, a 22% increase since 2017 [16]. To further represent the state of CS in Wisconsin, 3.3% of students reported taking a foundational computer science course in 2021–2022, 21% of these students were female, and Hispanic students were 1.3 times less likely to take one of these foundational CS courses than their white and Asian peers [16]. Milwaukee Public School District (MPS) is the largest school district in Wisconsin. MPS serves a student population of 77,746, with 88% being from minoritized student populations.

This research is in coordination with the preparation of the Urban Milwaukee for Pathways in Computer Science (PUMP-CS), an NSF grant that promotes equitable access to high-quality Computer Science education for all students in Wisconsin across grades K-12. Additionally, PUMP-CS is a collection of initiatives with the goal of ensuring that all Milwaukee Public School students have access to an equitable, meaningful, rigorous, and relevant inquiry-based computer science education. The Research–Practice Partnership (RPP) consists of The Learning Partnership, American Institute for Research, Marquette University, and Milwaukee Public Schools to assist MPS district leadership in developing healthy student CS identities through clearly defined CS pathways. Moreover, this partnership works with teachers and school administrators to provide high-quality professional training, curricula, and CS paths that further develop students’ computational thinking as an opportunity to improve educational and life outcomes.

## 2. Methods

### 2.1. Aim of the Study

This study, conducted through a grounded theory approach, investigated how students and teachers understand their computer science program participation and what factors contribute to their decision to continue in an early STEM K-12 pathway. The study utilized two overarching research questions that focus on exploring students’ opinions and thoughts on CS participation. The questions are

1. How do current high school students in computer science programming understand the connection between their identity and educational pathway participation?
2. Does early CS participation and teacher support create a “student perception” of a CS pathway (i.e., self-perception of continued CS participation on the next level) to computer science participation in college and beyond?

### 2.2. Grounded Theory

The study approached the interviews using a descriptive qualitative design based on Glaser and Strauss’s [40] grounded theory model. Grounded theory was used to give students and teachers a voice in how they perceive their participation in computer science programming. Saldaña [41] regards the grounded theory process as focusing on multiple participant populations as a group instead of a single case [42]. Humans are affected by the social world and require meaning to be continuously modified by experiences

and interactions with others [43,44]. The grounded theory aims to generate theories by establishing different concepts from the data that have been collected. Those theories are then analyzed through social contexts in which they will later be applied [40].

### 2.3. Respondents

This study consisted of eight teachers or students participating in the MPS's ECS or CSD computer science programming. The research team recruited interested teachers and emailed their classes to identify interested students. Four students between the ages 13 and 17 were selected from our student solicitation. Student and teacher names are located in Table 1. The research sample consists of four students and four teachers participating in either ECS or CSD computer science programming in the Milwaukee Public School District. Researchers used pseudonyms for student names.

**Table 1.** Student and teacher participants.

Student	Student Ethnicity and Gender	Student's Corresponding Teacher	Teacher Ethnicity and Gender	Grade	Participating CS Program
Peter	Asian (Hmong), Male	Jenny Nickles	Euro American, Female	10th grade	Exploring Computer Science (ECS)
Mark	African American, Male	James Dawson	African American, Male	11th grade	Exploring Computer Science (ECS)
Mary	African American, Female	Janet Torres	Latina, Female	9th grade	Exploring Computer Science (ECS)
Abigail	Latina, Female	Janet Torres	Latina, Female	9th grade	Exploring Computer Science (ECS)
NA	NA	Kevin Potter	Euro-American, Male	11th grade	Exploring Computer Science (ECS)

### 2.4. Exploring Computer Science (ECS)

The following section is a description and overview of the Exploring Computer Science (ECS) program, the program study for this project.

Exploring Computer Science (ECS) is a K-12 national program (curriculum and professional development) committed to democratizing computer science knowledge by increasing learning opportunities for all students at the high school level, with a specific focus on access for traditionally underrepresented students. The ECS program consists of a high school preparatory computer science course and a professional development program for teachers. ECS is an outgrowth of research that focuses on disparities and access issues along racial and socioeconomic lines. This research was also detailed in the 2008 book *Stuck in the Shallow End* [45].

The ECS curriculum consists of six six-week long units, covering Human–Computer Interaction, problem solving, Web Design, Introduction to Programming, Computing and Data Analysis, and Robotics. ECS also offers two units that can be used as alternates to either unit 5 or 6: “E-Textiles” and “Artificial Intelligence” [46]. The ECS curriculum is designed to encourage student inquiry and equity-based instructional practices. All students, particularly those in schools with high numbers of low-income students and students of color, are introduced to the problem solving, computational practices, and modes of inquiry associated with computer science. Moreover, the ECS curriculum is structured to align with college preparation coursework and Career and Technical Education pathways that include Information Technology; Engineering and Design; and Arts, Media, and Entertainment Technology [46].

### 2.5. Data Collection

Data collection involved semi-structured 30–45 min interviews [47]. 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 first author also conducted two impromptu 20–25 min Zoom meetings with MPS teachers after classroom visits.

Each interview was opened with the question “Why did you take a computer class?” followed by “How did you become interested in computers?”. This allowed the participants to talk about their experiences in their own words. We also raised questions on specific computer science and pathway needs, educational and social content, and information participants might desire to help their continued involvement with MPS pathway work. Following each interview, field notes were taken. These included brief data on the participants interviewed and observations made during the interview or classroom visit. Data collection stopped when theoretical saturation was reached [41].

## 2.6. Data Analysis

The research design used in this study was Corbin and Strauss’s [48] grounded theory. This design aimed to understand how students and teachers regard educational programming created to provide what we regard as “early career” and educational training for students of color and women to enter the STEM fields.

Data from the interviews were analyzed and categorized according to the constant comparative method of data analysis [48]. We collected data during the interviews, summarized it into different themes, and confirmed and modified it throughout the analyses. The data analysis started after the first interview and consisted of open, axial, and selective coding. After initial coding was completed by the first author, the findings and raw data were presented to two outside researchers to establish qualitative research validity and check reliability. The findings of this study are a collective effort of a three-member research team.

Open coding included repeated readings of the interviews and an in-depth line-by-line analysis of the data. When a new concept or unknown idea was raised in an interview, we consulted the literature and cohort of two outside researchers to help with meaning-making and coding. Utilizing open coding, data were coded under various headings according to their content to open up data and consistently compare themes and categories that emerged from subsequent interviews [41]. In the axial coding, categories were linked, with sub-categories describing the specific category. In the final selective coding, the categories were linked together, which resulted in a core category [41].

## 2.7. Coding Analysis

The analysis found five beneficial categories necessary for students’ and teachers’ participation in a STEM pathway: (1) Early Student Opportunities, (2) Awareness of Critical Educational Junctures, (3) Celebrating, Encouraging Success, and Wins, (4) Building Healthy CS Identity, and (5) Student Relationships. Table 2 explains how an inductive coding process labeled each connection to a given category.

**Table 2.** Coding category description and selection explanation.

Code	Description	Frequency
Early Student Opportunities	Instances of how early CS encounters encourage continued pathway participation.	65
Awareness of Student Movement within School District	Instances of building, teacher, and classroom changes and how these breaks in educational matriculation affected student and teacher opinion of CS participation.	61
Celebrating, Encouraging Success, and Win	Celebrating wins stimulates dopamine release in the brain, reinforcing the learning experience and strengthening a person’s sense of connectedness.	54
Building Healthy CS Identity	Self-concept, personality development, and values are all closely related to identity formation.	35
Student Relationships	Discussion on how educators work against harmful norms and cultivate relationships with students.	25



### 3. Results

The following section provides a comprehensive study of students and teachers engaged in computer science (CS) programming in Milwaukee Public Schools. Our research uncovers how the systems and policies of MPS shape their entry, teaching, and participation in a burgeoning educational pathway designed to guide students into the field of CS. While our focus is on a CS pathway, the insights we gleaned from our participants' CS journey are invaluable for districts aspiring to create pathways for students to college and careers. This research found five beneficial categories necessary for students' and teachers' participation in a STEM pathway: (1) Early Student Opportunities, (2) Awareness of Critical Educational Junctures, (3) Celebrating, Encouraging Success, and Wins, (4) Building Healthy CS Identity, and (5) Student Relationships. These findings were used to underpin our critical juncture conceptualization, providing practical implications for the design and implementation of CS Pathways in K-12 education.

We connect these areas to students' understanding of their race or ethnicity and career ambitions, particularly how teachers in MPS utilize a dual path in students' development to encourage career ambitions based on students' intrinsic interests and external experiences in mathematics and science course-taking as early as middle school [49,50]. Our student participants showed interest in computer science early in life; moreover, we found that students were fortunate to meet a teacher mentor, enter a CS program, or be encouraged by their community or family to have a vision of what CS could mean in the future. This happenstance or luck for our students to encounter internal (social) and external (educational) factors combined to create a process of reciprocity that ushered them into a pathway. This process of dual reciprocity is the foundation we use to conceptualize our notion of critical junctions in this research. Additionally, we consider our conceptualization of critical junctions to present broader questions for educators and curriculum designers interested in creating student success pathways into college and career. We consider these three areas, (1) Student Family Encouragement, (2) School and Community Engagement, and (3) Professional/Teacher Mentorship, as critical junctures for our participants and consider these in combination as necessary to students' entrance and successful continuation in an educational pathway. This research examines a CS pathway but we intend this work to speak to a larger notion of educational pathways within K-12 systems.

#### 3.1. Framing Pathways through Understanding Critical Junctures

The Center for the Advancement of Informal Science Education [7] defines a healthy CS identity as the belief that someone regards them as a science learner and "someone who (a) knows about, (b) uses, and (c) sometimes contributes to the field of science". The two young men of the study's intrinsic experiences (hands-on experience repairing electronic devices in their community) served as a driving force for a CS pathway and an opportunity to expand their interest in electronics repair. In contrast, the two young ladies of our study were encouraged and pushed into the CS pathway by their mentor and teacher (i.e., extrinsic factors). No matter how the students were funneled into CS programming, we know that for 3 out of 4, early encouragement and support served as the primary catalyst for developing their personal belief that they are a part of or could be a part of the science community, i.e., their CS identity.

We regard this encouragement by family, mentors (teachers), and access to STEM equipment as representing areas that we think schools should be watchful of when attempting to create educational or professional pathways into college and career. The personal relationships we found between students and teachers in MPS were a form of mentorship into a career and represented a significant aspect as to how our students began to connect their community knowledge into pathways that made the possibility real of CS being more than entertainment and rather, as an economic possibility for a future career.

The following section will focus on the five findings mentioned above that students and teachers identified as crucial in their entrance, participation, and continuation in early K-12 computer science pathways. Although this research focuses on CS education, these

five findings are how we conceptualize the idea of critical juncture, which we regard as a three-pronged framework (Table 3) that attempts to highlight the importance of Student Family Encouragement, School and Community Knowledge Production, and School Community Engagement as a process that connects learning pathways to community needs and concerns. Additionally, this research is intended to highlight how Teacher Care practices create Professional Mentorship opportunities through educational pathways into college and career.

**Table 3.** Educational pathway critical junctures framework.

Critical Juncture	Related Codes	Representative Example
Student Family Encouragement	<ul style="list-style-type: none"> <li>• Early Student Opportunities</li> <li>• Celebrating, Encouraging Success, and Win</li> <li>• Building Healthy CS Identity</li> </ul>	<p>“To be honest, when I was little, right, my dad kind of like know a lot about computer. And then he kind of teaching me, teach us things like downloading app, about how to like delete, how to sign out. And it kind of like, you know, it kind of interest me, you know (Peter, Interview 5/2021)”.</p>
School Community Engagement	<ul style="list-style-type: none"> <li>• Early Student Opportunities</li> <li>• Celebrating, Encouraging Success, and Win</li> <li>• Building Healthy CS Identity</li> <li>• Student Relationships</li> </ul>	<p>“My parents and teacher built my confidence, you know. They told me I can do anything. . .especially technology. Do you know? They were helping me with this stuff. . .And critics and haters, help, you know? That built my confidence, too (Mark, Interview 5/2021)”.</p>
Professional/Teacher Mentorship	<ul style="list-style-type: none"> <li>• Early Student Opportunities</li> <li>• Awareness of Student Movement within School District</li> <li>• Celebrating, Encouraging Success, and Win</li> <li>• Building Healthy CS Identity</li> <li>• Student Relationships</li> </ul>	<p>“When I had like questions and stuff, she took time out of her day, out of school hours, to open the Google Meet and help me go through some of the questions I was having and stuff. She didn’t have to do that, but she did (Mary, Interview 5/2021)”.</p>

Therefore, the following sections will examine the five findings through a qualitative vignette and explore how students’ and teachers’ experiences connect to the critical juncture framework described in Table 3. Although this ongoing research focuses on computer science education, we regard the five findings paired with our critical juncture conceptualization as essential to consider when developing educational pathways across subjects.

### 3.2. Critical Juncture 1: Student Family Encouragement (Utilizing Students’ Home Knowledge as an Entry Point)

Students’ ability to imagine themselves as a part of a field or a career path is a significant marker of their resilience to continue into college, specialized training, and careers [51]. For minoritized students, particularly those attending schools that do not have a tertiary educational tradition, the ability to imagine one’s future self becomes an organizational and social problem that may exacerbate their readiness to transition to college and fields that require post-secondary specialized education. The students we interviewed spoke to this notion, particularly with regard to how encouragement from their families and community helped them imagine themselves as members of the computer science community. Our participants focused on community trust through practices like computer repair, gaming, and general verbal and physical care and love practices. Family and community care and love practices are a commitment to taking care of ourselves and each other by creating safe spaces where people can share their feelings, concerns, fears, and hopes [52].

### 3.2.1. Peter's Story (Early Opportunities through Home and School Skills Building)

Peter, a Hmong immigrant student, started on his computer science path repairing computers in his home alongside his dad as part of a small repair business. During our interview, Peter spoke about his love of anime and interest in coding and computer animation, stating, "my inspiration would be like anime. Like even though I've watched a lot of cartoons and stuff, it's kind of like, it gives me motivation, you know, to maybe one day write cool stories". Although Peter, an Asian male student, is part of an over-represented group in computer animation, he stated that his teachers and family made clear that his love of anime could be cultivated and made real within the computer science field.

While working on computers with his dad, he imagined that computer repair was possible; but, it was not until he encountered the Computer Science Discovery (CSD) program during his middle school years that he believed he could be a part of the CS field at a higher level. His participation in programs like ECS, Technology Education and Literacy in Schools (TEALS), and Computer Science Discoveries eased him into things like coding, programming, and, to an extent, gaming (although he claims his classmates are bigger gamers than he is).

I got to high school... I start being serious... about my future, I think about my career... it was hard at first, teachers were helping me, I kind of felt this connection, you know? Like we could do anything together, you know? And that is kind of like—is one of the things that make me like do more computer. (Peter, Interview 5/2021)

Peter (similar to Mark, the student featured in our next section) demonstrates how consistent early exposure to computer science programming can help students imagine themselves in the field of computer science. For example, just taking the first steps of making the transition from a viewer of anime to a person who believes that they can create and write anime as a possible career, inspired Peter to continue with his CS training even when he found it difficult,

Like even though I watched a lot of cartoons and stuff, like, it gives me motivation, you know. I see what these people [who work in the animation field] in these movies and stuff are doing with their life and I kind of think of myself, you know, what am I going to do with my life when I grow up? What should I do? What, should I make things and prepare for my future, you know? This has help me think about my future. (Peter, Interview 5/2021)

Peter's family, particularly his dad, and the school's encouragement were vital to him entering a CS program and a larger CS pathway stating, "To be honest, when I was little, right, my dad kind of like know a lot about computer. And then he kind of teaching me, teach us things like downloading app, about how to like delete, how to sign out. And it kind of like, you know, it kind of interest me, you know?" However, similar to what Dou et al. [53] found, without students having significant first-hand exposure to CS programming or experiences, young people are at risk of being persuaded by socially divergent stereotypes of computer scientists that have the possibility of influencing them away from CS fields. Nevertheless, and most importantly, their teachers have prepared them to face the realities of a social milieu that has traditionally denied access to people in their social, racial, and economic classes.

### 3.2.2. Home Encouragement to Professional Training

Peter was influenced by his family and community's encouragement to take computer science courses in middle school, which he regards as directly leading to him staying within an educational pathway, long-term. We found that the two young men in our study were primed and ready to enter the STEM field and, by chance, they just happened to be in a district that was in the process of implementing CS programming in their schools. This example raises significant issues for the CS field and leads to questions of equity with

STEM professional training programs in districts. Are students from similar geographic locations and demographic backgrounds failing to find places to transition their home skills (in Peter and Mark's cases, using their knowledge of electronic repair) into a more extensive professional training program like CSD, ECS, and TEALS? Moreover, what becomes of students who are similarly building their STEM skill set within their community (home, church, community center, etc.) but failed to find a location to plug their skills into a formal pathway into college and career? According to our participants, it leads to non-participation, which continues the underrepresentation of minority people within the STEM profession.

### 3.3. Critical Juncture 2: School Community Engagement

The following section, told through Mark's story, focuses on teacher care and healthy identity formation as a driver of students into education pathways, notably how the mentorship of his teacher served as a catalyst to both strengthen his computer science skillset and community (racial and gendered) self-conception. During his interview, Mr. Dawson (Mark's teacher), who is also African American, male, and a former technology professional, described how he focuses on underrepresented students in his community by encouraging them to "not only imagine themselves entering into STEM careers but to explore how the STEM field can improve our community". This approach, which Mr. Dawson regards as a form of culturally responsive pedagogy, demonstrates how we conceive our second critical juncture component. Mr. Dawson's emphasis on pedagogical practices, informed by his students' community and racial and ethnic experiences, involves tailoring their educational journey to the specific needs and aspirations he and his students identify. For instance, if a student is interested in environmental science, Mr. Dawson would encourage them to explore how their interest and potentially newly gained knowledge could be applied to their local community. Indeed, during his interview, Mr. Dawson spoke about how he must build relationships with students based on genuine love and care for their future and that this love must center on students' experiences. This localization of pathway work or professional training is similar to what Sims [28] found in his research on why Black males fail to enter educational pathways. For Sims and Mr. Dawson, the economic and social reality of Black students, particularly males, made it difficult for them to sell how this long and winding road into the technology fields would be worth it.

#### 3.3.1. Mark's Story: Mentorship and Identity Construction

Early on, Mark found that he enjoyed "tinkering with mobile devices", which led him to start repairing and "jailbreaking" devices for other people in his neighborhood. Around 13, Mark's parents brought him his first computer, which allowed him to expand his neighborhood business and begin to think about entering the STEM field after high school. Around this time, Mark started participating in MPS computer science courses, where he learned to code and do app design. Mark describes this early investment of resources and training by his parents and his community as instrumental in moving from computer servicing as a hobby or repair business to acting as a possible career.

#### 3.3.2. Family, Community, School, and CS Identity

When we asked Mark how he found MPS's computer science programming, he informed us that he was not the first person in his family to "do computer class". He reported that his older sister also participated in MPS CS programming before graduation. Although his sister did not pursue a computer science career, Mark felt that she served as an example and entrée for him into the CS field. Additionally, Mark attributes his desire to continue and his understanding of the difficulties he will face as an underrepresented person in computer science to his teacher, Mr. Dawson, a former technology professional. Unlike the other students interviewed, Mark did not fear entering a field where he would be vastly underrepresented. He talked about having the confidence to succeed by using the "hate (discouragement)" as fuel to continue stating,

Mark: my parents and teacher built my confidence, you know. They told me I can do anything. . .especially technology. Do you know? They were helping me with this stuff. . .And critics and haters, help, you know? That built my confidence, too.

Researcher: The haters? The haters built your confidence?

Mark: Yup. (Mark, Interview 5/2021)

Mark's story describes a socialization process facilitated by an intentional practice designed by his teachers to build his CS identity. Mark's educational story is unique for a Black male and could be seen as a form of professional mentorship. He has a teacher who looks like him, from the technology sector he wants to enter, paired with his supportive family and community, who encourage him through resources, computer technician skills, and social expectations into a CS pathway. Nevertheless, what we found interesting about Mark's story is how he has internalized this social pressure into a self-expectation of greatness. He is using his community and family support as a catalyst to achieve his goals.

Indeed, Mark's understanding of his identity, or the process used to shape it, is not new or unique; it is difficult to attempt in a district with limited access to technology and teachers. During the interview, we commented on how unusual it was for him to have a teacher who looked like him in school, to which he agreed, and followed up with a description of other students like him, fixing phones and tinkering in their bedrooms but unable to find their way into a CS pathway, recalling,

Mark: So having a Black teacher means a lot. It means that you can do anything. You know? Having Mr. Dawson is a real blessing.

Researcher: Give me an example of what he has done to be such a great teacher.

Mark: Well, it makes me want to be a teacher, too, teaching other kids technology and stuff or how to use it. You know? Use codes and apps and stuff, you know? (Mark, Interview 5/2021)

### 3.3.3. Culturally Responsive Instruction (CRI) Bridges to Community

Mark's relationship with Mr. Dawson, similar to the young ladies in the next section, appears very strong and deeply grounded in responsive educational practices designed to connect Mark's skills to a pathway onramp. Mr. Dawson's work with students, particularly Black males, has distinctively shaped Mark's identity as a CS participant and future professional. Although Mark thinks the course could be a *"little more fun"*, his absorption of ECS and CSD principles is remarkable for building his healthy CS identity. When questioned about how the school can improve CS programming, he suggested the school provide students with more significant incentives and employment, *"like playing games to make money for laptops or computers"*.

Indeed, this notion of connecting race and community to CS professional and economic development was also raised by Mark's teacher (Mr. Dawson) during his interview, principally how, when recruiting students and developing culturally responsive lessons, it required him to consider the community context and social realities to make his lessons relevant to students, particularly his male students, stating,

[W]hen it comes to things such as like computer programming or just, or engineering or something like that, that's got to be something that's kind of relative. I mean, hopefully, fun when they do this, when they become part of the experience of being a computer programming or just, or engineering itself. (Mr. Dawson, Interview 5/2021)

Along with Mr. Dawson's understanding of the need for a unique entry for minoritized students (CRI) into computer science pathways, he also regards his instruction as needed to serve as a bridge between the school and social pressures his students encounter in their communities. Indeed, it appears that his pedagogical practice and philosophy is to cultivate a STEM vision within students as a future possibility,



Researcher: I find it really fascinating that you have that experience and that you are also a Black man in the field. What do you think that does for your students to see you as one of their instructors . . . do you think your students benefit. . . ?

Mr. Dawson: I think they get a benefit out of it because in the last couple days I see a couple of students start to kind of open up and kind of see that there is some benefit. . . I can tell them that experience of what I went through when I went through school to get this. Then all of a sudden, when I started to do this—look at it from the career aspect of it and see other guys doing it, it is like, “Oh, this is how [it could] be applied”. (Mr. Dawson, Interview 5/2021)

The influence of others’ expectations on young people’s educational outcomes may vary by the racial and ethnic group of the student and the type of “other”. Cheng and Starks’s [54] view of these expectations must be unpacked and examined with youth so young people can understand what is expected and required. However, thinking deeper about the care being enacted by Mr. Dawson is critical and essential to socializing his students to career and adulthood. Cheng and Starks [54] recommend considering pathways and teachers like Mr. Dawson in the form of mentor/mentee relationships to truly reap the relationship benefits.

### 3.4. Critical Juncture 3: Professional/Teacher Mentorship

The following two sections will focus on two participants, both young women of color, who shared Mrs. Torres as their CS teacher. We contend that these two young women are examples of students who would not have entered or continued their CS education and pathway participation without their teacher support and mentorship through coursework and matriculation concerns. Several studies identified encouragement from non-family members to be an essential motivator for young women as family support and contributed significantly more to women’s decision to pursue a CS-related degree than men [55]. This component of direct teacher support as a critical mentorship is how we divide these two women from our earlier students.

During her interview, Mrs. Torres (Mary and Abigail’s teacher) spoke about how she regards her role as a Latina modeling CS ability and passion to students just encountering STEM fields for the first time, stating,

I think of myself, and how I got involved, it was more of a manufacturing kind of way. Like I like to see how things run. And even with the—like, the robotics, I think females are a little drawn to that. Like the action side. . . I think when they have seen things be built from scratch and learn how they can put their own touches onto it, that’s where the creativity comes from. And that’s what I think needs to be more pushed when we talk about girls. (Mrs. Torres, Interview 5/2021)

Similarly to how Mr. Dawson served as an example to Mark, Mrs. Torres sees herself as an example to young women of the possibilities they can achieve within the CS fields: it is not just a boys’ club but a place that could be welcoming to everyone,

There were a few young women interested and is looking at computer science. They sometimes say it’s a ‘boys’ club.’ One of the students (Mary) are interested in CS just because she is thinking about becoming a doctor or getting into more of a, like a bio-ed field, and just felt—like she wasn’t sure how computer science fit into that. However, [Mary’s interest in medicine]. . . was the reason I had to use to get her to join us. (Mrs. Torres, Interview 5/2021)

#### 3.4.1. Mary’s Story: Celebrating, Encouraging Success, and Win

Mary, an African American student, started participating in CS programming in high school when she first encountered Mrs. Torres in the ninth grade. Additionally, Mary’s high school has a computer science course requirement, which forced her to take a CS class for the first time. She talked about fearing computer science classes and work during middle

school because she did not picture herself doing anything with computers, stating, “I felt like it was a good opportunity to learn something new, like nothing that I would have ever saw myself doing. . . I would have never thought it was what it is”. When asked when she overcame her fear of computers, she replied, “Honestly, this year when I took computer science. . . I wasn’t really a computer person, but I don’t know, this just opened up like a lot of different aspects for me to look at. . . It was fun, so I just liked it. So I don’t know”.

Mary goes on to talk about how Mrs. Torres helped her overcome her CS challenges like coding and programming. For her, coding was a challenge that she believed almost forced her to quit but her teacher kept her motivated to continue and finish the project that she was working on. Mary regards Mrs. Torres as her biggest supporter,

Researcher: Who was your biggest supporter when you decided, “Hey, I’m going to take a class”, or you have to take a class, right?

Mary: I think we had to, but. . . Mrs. Torres, she helped all of us understand and took her time with us, because it was new to all of us.

Researcher: What were some things she did to help you be more comfortable and be more involved?

Mary: When I had like questions and stuff, she took time out of her day, out of school hours, to open the Google Meet and help me go through some of the questions I was having and stuff. She didn’t have to do that, but she did. (Mary, Interview 5/2021)

We found it interesting that Mary saw her teacher, Mrs. Torres, as her biggest supporter, not her family or friends, which is how Mark and Peter regarded support in their lives. This understanding could be an example of Wang et al. [55], suggesting that non-family members are more critical to women in pursuing computer science degrees.

Indeed, when speaking to Mrs. Torres, she reports focusing on celebrating accomplishments for her students. When we asked her about Mary’s struggle with coding and how Mary viewed her support, she described it as an intentional process that required her to be sensitive to the vulnerable position Mary had—her being new to CS training and one of the few young women in the class and club. So she believed she needed to celebrate successes as a way to reinforce the lesson and as a way to build a strong relationship that allows her to push students forward, stating, “It is like a math lesson, things build on each other, and I have to get students to stay interested until they can see the whole picture (Mrs. Torres, Interview 5/2021)”.

### 3.4.2. Awareness of Student Progress and Within-District Mobility or Transience

Like many urban districts with open enrollment, Milwaukee suffers from what one of our teachers describes as a “fluctuating in-and-out system of students”. Children living in and outside the city of Milwaukee can attend any MPS school if seats are available. This fluidity in the student population profoundly affects the student–teacher relationship, particularly during middle school and high school transitions. Mr. Potter, a CS teacher in MPS, spoke about how he sometimes finds it difficult to build long-lasting sustainable bonds with students because of the volatility of student attendance in his school.

Our teachers highlighted breaks within the traditional student matriculation (changing school buildings) as a location of vulnerability for students within a CS pathway. For example, Abigail and Mrs. Torres knew each other in middle school and had already formed a deep connection before Abigail experienced her eighth grade to ninth-grade matriculation break. All the teachers pointed to these breaks or building changes in matriculation as probably one of the most troubling aspects to consider when creating a K-12 CS pathway. They also pointed to Milwaukee’s unique open school system and the difficulties of tracking students from eighth to ninth grades.

Additionally, these teachers pointed out that student movement within the district, because of social and economic issues like home evictions, crime, and jobs, was a year-round problem that made it difficult to form healthy relationships over a student’s 4-year

high school career. Nevertheless, on the student side, they were also concerned in their respective way about movement and matriculation break. Across student interviews, students spoke about the difficulties of transitioning from eighth to ninth grade and how this transition into “full-fledge pre-adulthood” included them beginning to access and decide their future career and life goals.

### 3.4.3. Abigail’s Story: Student Movement and Long-Term Teacher Care

Contrasting Mary with Abigail, you will find a similar theme of Mrs. Torres encouraging her to continue in the CS field. However, unlike Mary, Abigail knew Mrs. Torres in middle school when she took her first CS Discoveries (CSD) computer course. Abigail recalled struggling in her early experience in CS courses. However, she recalled how Mrs. Torres would take extra time to help her and encourage her to finish her CS Discoveries module. What is also interesting about Abigail is that she was going through a self-described difficult time during her middle school years and often struggled with depression and feelings of self-doubt in classes because of her fear of being at a new school and the uncertainty of being a “girl in middle school”.

She regarded her time in the CSD course as a positive outlet that allowed her to experience success and happiness. She particularly highlighted how Mrs. Torres created a classroom that would “push her” into pursuing her interests.

Well, I learned a lot of the new stuff, and considering in seventh grade, it like wasn’t the best year, but when I had computer class, I learned stuff there, and I’m learning more stuff now. . . I know more things than I did back in seventh grade. It was really calming when I would go to my computer class because it would always be fun, and we would be doing something, or we would continue on a project that we were doing. (Abigail, Interview 5/2021)

Additionally, she spoke about how Mrs. Torres would talk about her career and things she had done when she was young, particularly the idea that CS is not just a “boys’ thing” but something she could also be a part of. Indeed, she went on to explain that Mrs. Torres would point out that CS could be fun and that it could be a place for women interested in things like mathematics and problem solving.

Both Mary and Abigail demonstrate how a teacher’s care and intentional practices can motivate students, particularly female students of color, to enter a CS pathway. Mrs. Torres sees her pedagogical approach as encouraging students of color, focusing on women in STEM fields. Additionally, Abigail’s story of early CS opportunities was vital to her positive view of computer science as a possible career. Her ninth-grade school has a CS course requirement; however, when she reencountered Mrs. Torres in the ninth grade, she drew on her previous positive experience and personal connection to CS programming to ease her back into a CS pathway. This also allowed Mrs. Torres to continue to mentor her in the CS pathway that MPS was constructing. Abigail cited her relationship with Mrs. Torres as her primary reason for becoming interested in pursuing CS in college, further highlighting the importance of culturally responsive intervention and the mentorship important for young women entering STEM.

## 4. Discussion

Ladson-Billings [56] developed three criteria that undergird culturally relevant pedagogy (CRP): “an ability to develop students academically; a willingness to nurture and support cultural competence of students; and the development of a sociopolitical or critical consciousness” (p. 483). The teachers in her research believed “in a Freirean notion of teaching as mining” (p. 479) or drawing out already existing knowledge. This belief aligns with research on students’ funds of knowledge that has shown that children bring knowledge rooted in their home cultures to school [57]. Although this research is not focused on student “funds of knowledge”, we believe this social science research orients you (the reader) into a mind of understanding how students’ belief systems and teacher care and knowledge of students’ home and community life influence how they interact

with educational pathways. For communities and school districts like MPS, leaders and practitioners must consider the social realities of students, such as economic opportunities and precarious social conditions, that can impact their students' educational journey [58].

Through what we regard as professional mentorship, teacher care, and intentional cultural responsiveness, we believe our teachers serve as a bridge connecting these components to a reciprocity process that creates onramps and forward movement for students to stay and continue within the pathway. Indeed, we also regard this research as posing larger questions for practitioners and scholars interested in educational pathways, particularly those interested in understanding students' lives and goals and connecting those social lives to academic policies and practices that account for the students' lived experiences. Moreover, we regard each framework area as unique in how students enter, maintain, and sustain their participation in CS preparation. For example, we consider home communities as a source of motivation and skills building, their teacher's mentorship as an onramp into a formal pathway, and school community engagement as a source for culturally responsive instruction. Although we regard our conceptualization of "critical junctures", a term referring to pivotal moments or stages in the educational journey, as playing out in three areas: (1) Student Family Encouragement, (2) Professional/ Teacher Mentorship, and (3) School and Community Engagement, we would like to explore how teachers and family care and mentorship practices serve as foundations for student CS participation.

We regard the students' background and pathway into STEM education as essential information gained for this study. For example, Mark and Peter attribute their home experiences with computer science repair as a significant driver to their interest in CS. Indeed, Peter and Mark's family and community encouragement through resource development and social support built what the young men described as an interest in wanting to pursue computer science training through an educational course in middle school. In our opinion, if we zoom out from the two young men's stories, we find an interesting dynamic at play that often goes unaccounted for when schools and districts begin thinking about constructing educational pathways into college and career—that of community (including immediate, extended, and fictive family) support and encouragement as an onramp into a pathway [59]. With our participants, we found a unique situation of a community filled with electronic devices but without cheap alternatives for repair, to which small informal electrical repair businesses spring up [60]. We conceptualize the critical junctions of community support and encouragement to account for informal paths of professional training that our participants encounter in their home communities [61].

Additionally, our participant involvement in what we refer to as an "informal economy", a type of economic activity that is neither taxed nor monitored by a government, serves as a type of informal professional development and raises questions about how the district can tap into these informal networks, finding students primed to participate in their formalized educational pathways. As stated earlier, our participants, by chance, just happened to be in a district that was implementing CS programming in their particular schools. Our students were known to their communities as young persons skilled and interested in CS but were unknown to policymakers and leaders interested in identifying interested CS students. As we close this section, we again raise the following question: if we know from our student interviews that family and community drive students into a CS pathway, how can policymakers tap into parental and community knowledge to bring students into pathways? Khalifa [62] considers this to be conducted through leaders serving as advocates and social activists for community-based causes in the school and neighborhood or, said differently, engaging students' parents in their community context.

#### 4.1. Professional/Teacher Mentorship

Estrada et al. [24] and their research on mentor–protégé dynamics show how their understanding of mentorship opportunities collated with how our participants entered the CS field. Estrada et al. [24] see that mentorship happens best when there is (1) instrumental support, providing resources and opportunities for the protégé to engage in goal attain-

ment [26], (2) psychosocial support, and (3) relationship satisfaction (including feelings of trust, empathy, respect, and connectedness). Teacher care, defined by Louis et al. [63], is seen as a “process of helping another person grow in his or her ‘own right,’ that is, not bound up in the interests and well-being of the carer but in the one being cared for... (p. 311)”. If we take a bird’s-eye view of how the students entered and continued into the CS pathway, we find mentorship at the center of our students’ motivation and identity formation. Each student encountered a mentor who focused their intrinsic and extrinsic values on building their career, job prospects, and social position within the larger society. For example, we can see through Abigail, Mark, and Peter’s experience how their interests (fixing electronics, playing computer games, and using coding and computer work as an escape from complex life issues) and motivation shifted positively toward a CS future through their connection to mentors concerned with not only academic success but also social success.

Research has found that students most motivated to pursue STEM degrees became interested in STEM through childhood extracurricular experiences with nature and astronomy and that relatives or friends were the most substantial factors for igniting initial student interest in STEM [64]. Across our student interviews, this was the case; each student recalled how their early experiences interacting with elements of computer science coupled with a “mentor’s push” drove their desire to learn about CS principles. For example, Abigail’s early experience with CS learning in her seventh-grade year (the year she began Computer Science Discoveries) was marked by negative schooling experiences; however, her interest in coding and games gave her a reason to come to school and dream about becoming a computer scientist through Mrs. Torres’s example. This early experience, coupled with the love and support she received from her teacher, marked a turning point for her. Her teacher was instrumental in her continuing in school and more instrumental in her returning to CS programming in high school. Although each student encountered mentorship in a unique form, each student agreed that their teachers served as a triggering event that helped them begin to identify within the field of computer science.

#### Building Student CS Identity and Confidence through Mentorship

Mrs. Torres also regards forming healthy relationships as a tool to encourage young women to enter an educational pathway. A significant issue in research about women is that they see themselves as lacking confidence in performing tasks [65]. For example, the men demonstrated self-assurance when speaking about their CS abilities and knowledge, while each woman used language indicating unsureness. Mrs. Torres described her approach as building “*young women’s confidence*” and ensuring they see themselves as equally deserving to be in the room. Mr. Dawson also raised this issue about how he interacts with his students. This demonstrates how culturally responsive teachers could be a critical tool to encourage minoritized students into pathways. Moreover, these two examples illustrate the importance of diversifying mentors (teachers and industry professionals) when designing pathways into industries struggling to diversify.

#### 4.2. Culturally Responsive Teaching and School Community Engagement

Recent studies have found that cultural mismatch negatively impacts student achievement [66]. Indeed, according to scholars like Banwo [67], it is important for all teachers, regardless of their race or ethnicity, to become culturally responsive to meet students’ needs and concerns that arise from their communities. Culturally responsive pedagogy (CRP) is not just a term but a crucial approach that underscores the importance of both relevancy and culture in student learning [56,68]. CRP is defined as “using [students’] cultural orientations, background experiences, and ethnic identities as conduits to facilitate their teaching and learning” [69] (p. 614). During Mark’s interview, he spoke about how his African American male teacher exemplified what he could become. Mr. Dawson (Mark’s teacher) also talked about the mentorship aspect of his job and how he regards his unique position as “first being Black and second being a male in education”, allowing his students



to see themselves in the field. He sees CS programming as an opportunity for young men, particularly Black men, to find a career path of success. Moreover, Mr. Dawson can walk Mark through the pitfalls and dangers he faces as a person from the field. What we see as Mr. Dawson's most critical work is his unique understanding of the Black male psyche or "the male psyche". During his interview, Mr. Dawson spoke about what he sees as a lone wolf personality and phenomenon within the young men he teaches. Although this could be classified as care, it is also a cultural nuance that Mr. Dawson, a Black male, has a unique cultural window of.

Fries-Britt and White-Lewis [70], discussing Black males' experiences in STEM classrooms, found that when Black males perceive positive faculty behaviors, they make deeper connections, which opens a space for increased learning and trust. Mark and Mr. Dawson are acting out this relationship pattern. Mr. Dawson can cut through Mark's "cool posturing" to his desire to succeed in the field of computer science. For Mr. Dawson, Mark's story also takes on a much deeper and larger social phenomenon that troubles him when working with young Black males: the need to separate themselves from the community. Studies have shown that as Black men become more successful, there is an increase in depression and chronic medical conditions [71]. This factor is something very few people outside the Black male experiences are aware of; thus, mentors like Mr. Dawson see themselves as responsible for orienting younger Black men into the social reality of being Black and successful. In shaping Mark's CS identity, it becomes essential that Mr. Dawson uses an intersectional lens to prepare Mark for his chosen field.

#### Mentorship (Teacher Support) Informed by Community Issues

Another concern for our teachers was the economic and social issues associated with student movement (changing schools). Milwaukee has one of the county's highest eviction rates, which creates a dynamic process of a year-round movement that the teachers describe as interfering with their ability to form long-term healthy relationships over a student's 4-year high school career. The students also raised concerns about movement and matriculation breaks. They were concerned with the difficulties of transitioning from eighth to ninth grade and how this transition included them beginning to access and decide their future career and life goals. Additionally, they raised concerns about unequal access to CS education, with the notion that not every school has CS classes. There is a real possibility they could start training at one school only to abandon their studies after moving to a school without a CS class.

## 5. Conclusions

Strengthening the bonds between school, community, and family has long been a point of focus in the school improvement literature; however, what we regard as new and in need of greater exploration is the connection between culturally responsive instruction and students' community and home skills training as keys to sustaining educational pathway participation. When K-12 systems consider enacting educational pathways, this attention to student home and community knowledge should be in conjunction with more external infrastructures as critical information for policymakers. With our participants, for example, we see this attention to student home lives playing out in the process of trust building through practices that encourage critical reflection among students and educational professionals. Indeed, this intentional culturally responsive practice by the teachers includes designing courses that enable students to see their unique cultural practices or mentorship from an industry professional or 'teachers' serving as examples of future possibilities for students.

We wanted to undertake this research to amplify the voices of students and teachers in a district in the early stages of establishing a CS pathway. We see students' home knowledge as plugs searching for a socket connecting them to a more extensive system that is still yet to exist. Most school systems function where the school and its policies are centered, leaving a deficit model in which parents, students, and the community are to be

plugged into the current limiting infrastructure [72]. In this study, the students and teachers reflected on their experience and participation in professional training that also served as the initial access to a pathway. These voices of the students and teachers have informed the development of a framework of critical junctures (see Table 3). Their stories and experiences (plugs) describe a dynamic and fluid process requiring attention and outreach to create an environment that forested students' extrinsic and intrinsic values (socket). When centering students' experiences in redesigning educational pathways, we create new sockets that better fit their inherent plugs. In future work, we will apply this framework across a wider set of contexts to refine and validate the framework.

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