Pathways and Pipeline and the Growing Pains of Creating a Computer Science Pathway UCEA 2023

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Full Abstract

Practitioners and Scholars interested in developing computer science (CS) pathways must understand the nuance lives and goals students encounter when navigating the tricky lessons of life. For many watchers of the STEM field, the underrepresentation of women and minorities serves to fortify our society's opinion and imagination of what or who is a scientist and the risk of creating processes that fail to "tease out" ethnic minorities and women's experiences within the larger STEM field (Alfred, Ray, & Johnson, 2019). The following research article explores four high school students' experience with computer science programming in the Milwaukee Public School system in three focal areas (Supporting Student Imaginings, Building a solid foundation of identity and Student Scaffolding, Mentorship, and Support). The students describe how their desires, fears, family, and dreams affected how they arrived at their computer science program and how it drives their burgeoning computer science identity. Moreover, this research yielded a new framework (1) Early student opportunities, 2) Awareness of Critical Educational Junctures, 3) Building Healthy CS Identities, and 4) Celebrating, Encouraging Success and Wins.) that we consider important when thinking about healthy and productive computer science pathways that target underrepresented persons within the STEM field.

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Purposes

The research examines how high school (HS) computer science (CS) students appreciate and rate their participation in middle school CS courses as a catalyst to future computer science participation. The research explores how early (elementary and middle school) CS program participation encourages students to develop healthy computer science and STEM identities. Additionally, the research seeks to understand if early CS participation encourages students to continue their computer science careers into high school and college years.

Perspective

For some time now, there has been a concern that the United States does not produce a sufficient number of workers and majors in CS fields in order to remain globally competitive (Sass, 2015). Of particular concern is the underrepresentation of women and ethnic minorities in STEM fields. When considering why this underrepresentation continues, past research has suggested that the field needs to pay greater attention to how Black and Latino workers are seeded and grown into STEM professions. This research sought to support that goal by measuring in a qualitative way how HS students in the Milwaukee Public School system regard their participation in early computer science programming. We sought to understand how Milwaukee's school leaders can use their city's unique history and place within the state of Wisconsin to design, fortify, and better students' computer science experience. Although Milwaukee uses a suite of different computer science programs, we were interested in knowing which programs help students develop their CS identity and desire to continue in computer science in college and beyond.

The Study

This research examines students' computer science identity and interest in computer science as a career in Milwaukee Public Schools (MPS) computer science programs. The research sought to understand better how ECS encouraged students and teachers to develop their computational thinking and computer science identity. Through a series of one-on-one interviews with Milwaukee Public Schools HS students and analysis of previously collected program survey data, the researchers attempt to connect middle school computer science program participation to the prospect of continued computer science participation in college and beyond. Moreover, this research sought to understand how early CS interventions could influence how students understand their place in the larger conversation of STEM jobs and career equity.

Research Question

1. How do current MPS high school students in computer science courses understand their computer science identity? Does early participation in middle school CS programming create a "student perception" that they will continue computer science participation in college and beyond?
    a. How can student perception improve the MPS computer science pathway?
    b. Do early computer science interventions increase students' desire to enter STEM fields in college and beyond?

c. Why did MPS students initially enter the MPS computer science pipeline? Why did students initially want to take a computer course in middle school?

Research Site

The study was conducted in Wisconsin, a mid-western state of the United States. Milwaukee Public School District is the largest school district in the state of Wisconsin.

Participants

The research sample consists of students and teachers participating in computer science programming in the Milwaukee Public School District. The authors interviewed ten students and six teachers.

Data Analysis

The lead author analyzed interview data using deductive coding methods (Miles & Huberman, 1994; Saldaña, 2009). We analyzed data that identified emerging patterns and themes. This exploration yielded three primary focus areas.

Preliminary Findings

Framework

The research yielded a new framework, based on interviews, that is categorized by four characteristics (See Chart 1): 1) Early student opportunities, 2) Awareness of Critical Educational Junctures, 3) Building Healthy CS Identities, and 4) Celebrating, Encouraging Success and Wins. We hope this new framework will supplement researchers' and practitioners' ideas of what can be found within an effective CS Pathway in order to have students pursue futures of work.

INSERT CHART 1

1) Early student opportunities (Peter's Story)

Peter, a Hmong immigrant student who started on his computer science path repairing old computers in his home alongside his dad as part of a small repair business. While working on computers with his dad, he imagined that computer repair was a possibility, but it was not until he encountered the Computer Science Discoveries (CSD) program during his middle school years that he believed he could be a part of the CS field. Peter demonstrates how consistent early exposure to computer science programming can help students imagine themselves in the field of computer science.

2) Awareness of Critical Educational Junctures (Mark's Story)

Mark, an African American male, also found that he enjoyed tinkering with mobile devices early on, which led him to start fixing and "jailbreaking" devices for other people in his neighborhood. Mark's story is describing a process of socialization that built his CS identity. He has a teacher that looks like him, from the technology sector he wants to go into. He has a supportive family pushing him through resources and social expectations into a CS pathway. He describes many

students like him, fixing phones and tinkering in their bedrooms but unable to find their ways 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?* (Interview 5/2021) "

Mr. Dawson (Mark's Teacher) can walk Mark through the pitfall and dangers he faced as a person from the field. What we see as the most critical work Mr. Dawson is doing is his unique understanding of the Black male psyche or "the male psyche."

3) Building Healthy CS Identities and 4) Celebrating, Encouraging Success and Wins (Mary and Abigail's story)

Both of Mary and Abigail's stories are similar but different in a couple of fundamental ways. Mary, an African American student, started her involvement in CS programming in high school when she first encountered Mrs. Torries in the ninth grade. Additionally, her 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 did she overcome 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*." (**This section was shorten to fit the 3 page limited**)

Conclusion: Framing the Pathways (Characteristics of a CS pathway)

We found that early support and encouragement to enter STEM pathways was critical to our students building their CS identities. For the two young men of the study, their intrinsic values (families and hands-on experience repairing electronic devices) served as a driver into a CS pathway and an opportunity to expand their interest in electronics repair. In contrast, the two young women were encouraged and pushed into the CS pathway by their mentor and teacher (extrinsic values).

Works Cited

Alfred, M. V., Ray, S. M., & Johnson, M. A. (2019). Advancing Women of Color in STEM: An Imperative for U.S. Global Competitiveness. *Advances in Developing Human Resources*, 114- 132. Retrieved from https://journals.sagepub.com/doi/pdf/10.1177/1523422318814551

Code.org. (2019). *The state of K-12 computer science.* Seattle: Code.org. Retrieved from https://code.org/files/Code.org-Annual-Report-2019.pdf

Code.org. (2021). *Computer Science Discoveries, Curriculum Overview.* Seattle: Code.org. Retrieved from https://docs.google.com/document/d/1hstUHTGIdvtPP0TDdEfQeXG3zQ0q6ys237n2BY9CQmg/preview

Eccles, J. S., Adler, T. F., Futterman, R., Goff, S. B., Kaczala, C. M., Meece, J. L., & Midgley, C. (1983). Expectancies, values, and academic behaviors. In J. T. Spence, *Achievement and achievement motives: Psychological and sociological approaches* (pp. 75- 146). San Francisco, CA: W.H. Freeman.

Funk, C., & Parker, K. (2018). *4. Blacks in STEM jobs are especially concerned about diversity and discrimination in the workplace.* Washington: Cary Funk; Kim Parker. Retrieved from https://cdn.ymaws.com/www.sidnet.org/resource/resmgr/DI_Tool_Kit/Pew_Research_Center_STEM_and.pdf

K–12 Computer Science Framework. (2016). *K–12 Computer Science Framework.* National Math+Science Initiative. Retrieved from http://www.k12cs.org

K–12 Computer Science Framework. (2016). *K–12 Computer Science Framework.* K–12 Computer Science Framework. Retrieved from https://k12cs.org/wpcontent/uploads/2016/09/K%E2%80%9312-Computer-Science-Framework.pdf

Kram, K. (1985). Mentoring at Work: Developmental Relationships in Organisational Life. *Administrative Science Quarterly. vol. 30(3).*

Parker, M., & Guzdial, M. (2016). *Equity Versus Equality: A Proposed Study of Issues of Justice in Computer Science Education.* Chicago: Workshop on Exploring Social Justice, Design, and HCI. Retrieved from http://depts.washington.edu/tatlab/socialjustice/wpcontent/uploads/2016/02/Parker-Equity-Versus-Equality-A-Proposed-Study-of-Issues-ofJustice-in-Computer-Science-Education.pdf

Sass, T. R. (2015). *CALDER Working Paper. No. 125.* Washington DC: American Institutes for Research.

Sims, J. J. (2018). *Revolutionary STEM Education: Critical-Reality Pedagogy and Social Justice in STEM for Black Males (Educational Psychology).* Pieterlen and Bern: Peter Lang Inc.

Wigfield, A. (1994). Expectancy-value theory of achievement motivation: A developmental perspective. *Educational Psychology Review. volume 6*, 49- 78.

Chart 1: Opportunities and Dangers for the Promotion of Healthy CS Pathway Entry

Early Opportunities CS Participation	Critical Junctures (Identify Areas of Criticality)	Intentional focus on building students CS Identity	Celebrating, Encouraging Success and Wins
• Students have access to CS programming before High School • Using students interests like (repair, tinking, and creativity) as markers of students interested in STEM	• Weak spots in the model (for example, eighth to ninth break) • Utilized programs and models like "Freshman on track" early warning indicator (If a student fail a class, it raises an automatic red flag of non-graduation)	• Train teachers and program operators to have an intersectional lens when building student identity (for example, African American males might have different needs than African American women based on social traditions, expectations, and customs) • Connect CS training and programming to student social realities • Have conversations with students about their underrepresentation in STEM. • Help students prepare for marginalization	• Teachers of the study took time to encourage students to reflect on success • Student success was not siloed, CS programming in MPS, encourage students to work in groups and support each other, therefore concerns like competition was somewhat mitigated, in favor of a communitarian praxis. • Teachers also used students' home skills to encourage success, the students believe they could succeed because they were succeeding at home