Inspiring and Preparing Underserved Middle School Students for Computer Science: A Descriptive Case Study of the UNC Charlotte/ Wilson STEM Academy Partnership

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Abstract

Students from underrepresented populations—females, working class, and youth from marginalized racial/ethnic groups—are less likely than their middle-class Asian and White male peers to study computer science (CS) in college. The dearth of CS undergraduates from these groups contributes to projected labor force shortages. Sources of the dilemma include weak or absent inspiration and CS preparation in middle schools and negative stereotypes suggesting certain groups do not belong in CS. This case study describes three years of a community collaboration between a local university and a nearby middle school attended by primarily low-income students of color. The University of North Carolina Charlotte/Wilson STEM Academy Partnership focused on undergraduates majoring in CS teaching monthly workshops designed to inspire and academically prepare the middle schoolers for college and CS majors by teaching them coding and computational thinking while also challenging stereotypes about who belongs in CS. Post-workshop assessments, reflective essays, interviews, and administrative data were thematically coded. Findings suggest the workshops sparked interest in college and CS, undermined toxic stereotypes, and nurtured the academic self-confidence of middle schoolers. The Partnership provided the undergraduates with opportunities to meet their

own academic goals while "paying it forward." Results suggest that the Partnership can serve as a model starting point for disrupting the disproportionalities in female and underrepresented minority students in CS.

Key Words: middle school, computer science, community–university partnership, racialized minorities, females, college readiness, careers, majors

Introduction

The United States' economy and basic scientific research foundations require increasing numbers of adults trained in the sciences. Projected shortages of appropriately educated adults for occupations in health care, education, manufacturing, media, public health, security, transportation, and the built environmental infrastructure are looming (Georgetown University, 2021; Justice et al., 2022; Veenema et al., 2022). The COVID-19 pandemic made painfully clear that access to the intersection of education and technology—including devices for virtual learning, high speed internet, and courses in technology—remains highly stratified by social class, rurality, and race/ethnicity in the nation's secondary schools (Kamenetz, 2022). For a variety of reasons, too many secondary schools fail to inspire or prepare youth for pursuing the study of science, technology, engineering, and mathematics (STEM; Business-Higher Education Forum, 2011). This is especially true for the field of computer science (CS). Far too many high school graduates enter the workforce and higher education without an interest in or academic skills for pursuing CS (Code.org, 2021).

At the same time, social norms suggesting women and certain ethnic groups are not optimally suitable for scientific or technical careers persist in popular culture, many families' ethos, secondary school curricula, instructional practices, and school organizational characteristics (Archer et al., 2010; Cheryan et al., 2015; Fisher & Margolis, 2002; Hanson, 2008; Margolis, 2010; Master et al., 2021; Xie et al., 2015). At present, the vast majority of students studying technology in the U.S. are males from middle-class White, South Asian, or Asian Rim ethnic groups such as Chinese, Japanese, or Korean (Fry et al., 2021). Lower-income youth from all racial/ethnic backgrounds, females, and students from Black, Latino/a, Native American, South Asian, and Asian and Pacific Islander (AAPI) backgrounds (including Southeast Asian nations, Guam, and Hawaiian, Polynesian, Melanesian, and Micronesian ethnic groups) are underrepresented in CS relative to their proportion of the overall population. Because individuals with these backgrounds are relatively absent from college CS majors, the current 21st century domestic technology labor

force only draws from a pool with more than half of the adult population missing. Moreover, because CS careers are stable, prestigious, and relatively well-paying, those precluded from the technology workforce face an additional obstacle to upwardly mobility.

Together, these trends require a multipronged response aimed at different aspects of this complex challenge. Stakeholders readily acknowledge that the uneven quality of secondary education looms large as a significant source of the apparent dearth of STEM-ready students. This article is a descriptive case study of an intervention designed to improve the likelihood that low-income, female, and underserved racial/ethnic minoritized middle school youth will be inspired to gain the skills necessary for pursuing CS in high school and college. The article describes the first three years of community collaboration between the College of Computing and Informatics (CCI) at the University of North Carolina at Charlotte (UNCC) and the Wilson Middle School STEM Academy, one of the 49 middle schools in the Charlotte-Mecklenburg School district. The UNCC/Wilson STEM Academy Partnership (henceforth, the Partnership) offers academic and psychosocial support for a cohort of motivated Grade 6, 7, and 8 students enrolled in middle school CS at Wilson. The Partnership also provided the undergraduates with a service learning opportunity that complemented their own lived experiences as a female or low-income and racially marginalized secondary student with aspirations to pursue CS.

Since 2019, the Partnership workshops have been designed and delivered by the UNCC undergraduates as part of a service learning course. Workshops provided Wilson students with hands-on, informal, supplemental instruction in technology skills; support for developing their CS identity; inspiration for college aspirations; and exposure to non-stereotypical gender and race/ethnic CS role models who challenge societal norms about who can become computer scientists. The workshops offered the undergraduate tutors/mentors a host of psychosocial and academic experience that helped prepare them to be successful professionals in the tech fields. The Partnership offered the community an opportunity for the CCI and the Charlotte-Mecklenburg School district to collaborate on achieving complimentary goals.

The immediate aims of the Partnership were to inspire middle school pupils to consider college and CS careers, to develop introductory coding and computational thinking skills, and to gain self-confidence as CS learners through informal supplemental workshops. The Partnership also offers UNCC undergraduates an opportunity to sharpen their own CS identities and "pay it forward" by mentoring and assisting the next generation of youth. The long-term goal of the Partnership was to develop a model intervention that will help address the low levels of interest in and weak preparation for college CS

majors, particularly among groups of students currently underrepresented in the field. Another long-term goal addresses both institutions' desire to seize the opportunity for town–gown collaborative efforts that advance both schools' goals centered on increasing low-income, female, and underserved minoritized youth majoring in CS.

This descriptive case study details the aims, history, and components of the Partnership and its supplemental workshops. The article connects the Partnership's components to the larger literature about CS education, especially for younger members of underserved populations. Following a review of relevant literature, the manuscript identifies the research questions that guided this study, the methods used in it, and findings from the Partnership after its first three years. The article concludes with implications of the UNCC/Wilson Partnership as a model for beginning to address the disproportionalities central to the current and projected tech challenges in North Carolina and across the nation.

The Contours of the Underrepresentation Problem

Nationally, females, low-income students, and youth from underserved racial/ethnic minoritized groups enroll as college CS majors at rates relatively lower than their share of the undergraduate population. As of 2019, 19% of U.S. undergraduates pursuing a CS degree or related major are women, 23% are Asian, 5% are African Americans, 11% are Latino/a, and 45% are White, with multiracial and international students comprising the remaining 16% of CS majors (Zweben & Bizot, 2022). With the exception of Asian male students from India and the Pacific Rim nations of China (PRC), Japan, Korea, and Taiwan, proportions of CS undergraduates who are female, AAPI, Black, Latino/a, Native American, and White are smaller than their share of the overall undergraduate population. The potential lost talent has negative implications for meeting the nation's labor force demands in occupations requiring technology degrees and for the individuals' social mobility given the prestige and compensation associated with technology occupations.

The challenges to enrolling as CS majors faced by underrepresented students are rooted in a variety of factors including weaker secondary school academic preparation, fewer role models, and greater lack of financial resources for college compared to more affluent White and Asian male undergraduates. Prior research has revealed numerous obstacles to the pursuit of CS over the course of these students' K–12 educational career. Obstacles often include lack of access to college preparatory curriculum, to rigorous math and science sequences, or to highly qualified teachers in low-resourced secondary schools (Bottia et al., 2021; Code.org et al., 2021; Fisher & Margolis, 2002; Margolis, 2010; North Carolina Department of Public Instruction, 2022). While these struc-

tural factors present significant external obstacles to preparation for pursuing CS, normative and cultural forces can also lead to some students opting out of technology career paths. For female students and youth from low-income underrepresented racial/ethnic groups, there is often weak or absent inspiration, encouragement, or a sense of belonging in the CS field (Rainey et al., 2019; Zweben & Bizot, 2022). Adults and adolescents from underrepresented groups often have misconceptions of what it means to be a computer scientist, and because of absent role models or mentors, they often are uncertain that people like them have a place in the field (Archer et al., 2010).

Sparking Interests in CS During Middle School

Students begin to think about their future careers during their early adolescence (Archer et al., 2010; DeJarnette, 2012; Hall et al., 2011; Hammack et al., 2015; Morgan et al., 2013; Settle et al., 2012; Wyss et al., 2012). They can be influenced at home, by role models in their immediate lives, popular culture, their communities, and by career counseling in school (Rogers & Creed, 2011). Secondary schools can be important agents for disseminating career information, particularly for students who do not have access to this information from family members in STEM occupations (Deslonde, 2017). However, not all counselors and teachers in middle and high school are well-informed about STEM occupations and may therefore be unable to guide students to STEM careers (Bottia et al., 2021; Engberg & Wolniak, 2013; Hall et al., 2011; McKillip et al., 2012; Woods & Domina, 2014). When lack of career information is compounded by the prevalence of negative stereotypes about who does or does not belong in STEM, high school students from lower socioeconomic class families, marginalized gender, or racial/ethnic groups can face a toxic brew of misinformation (Hanson, 2008; Palmer & Wood, 2013).

For these reasons, middle school is a developmentally appropriate time to begin youths' preparation for the pursuit of STEM in college. Numerous studies indicate that the middle school years are a suitable time to provide the academic skills, inspiration, and preparation for succeeding in high school STEM (Rogers & Creed, 2011; Settle et al., 2012; Wyss et al., 2012). During middle school adolescents begin to form perceptions of various occupations they may wish to pursue (DeJarnette, 2012; Hall et al., 2011; Hammack et al., 2015; Morgan et al., 2013; Rogers & Creed, 2011; Wyss et al., 2012). If they are immersed in stereotypical accounts of occupations suitable for people like themselves, they are unlikely to challenge the gendered and racialized norms of who can and cannot pursue certain careers. If they rarely encounter gender and racial/ethnic role models who undercut notions of who belongs in CS, they are unlikely to aspire to technology careers (Hall et al., 2011; Hanson, 2008;

Palmer & Wood, 2013). If youth are unsuccessful in obtaining the motivational and academic foundations in middle school, they are unlikely to enter college ready for STEM.

Based on the review of the literature that points to obstacles for greater participation in CS by youth from marginalized groups, several directions for action emerged and led the authors to develop an intervention designed to address them. Figure 1 presents the logic model of the UNCC/Wilson Partnership, which is designed to combat the lackluster inspiration, weaker academic preparation, missing role models, and negative stereotypes of who belongs in the technology field that often become barriers to majoring in CS. The Partnership begins to address these barriers for a group of low-income, female, or racially minoritized youth who attend Charlotte-Mecklenburg School's Wilson STEM Academy.

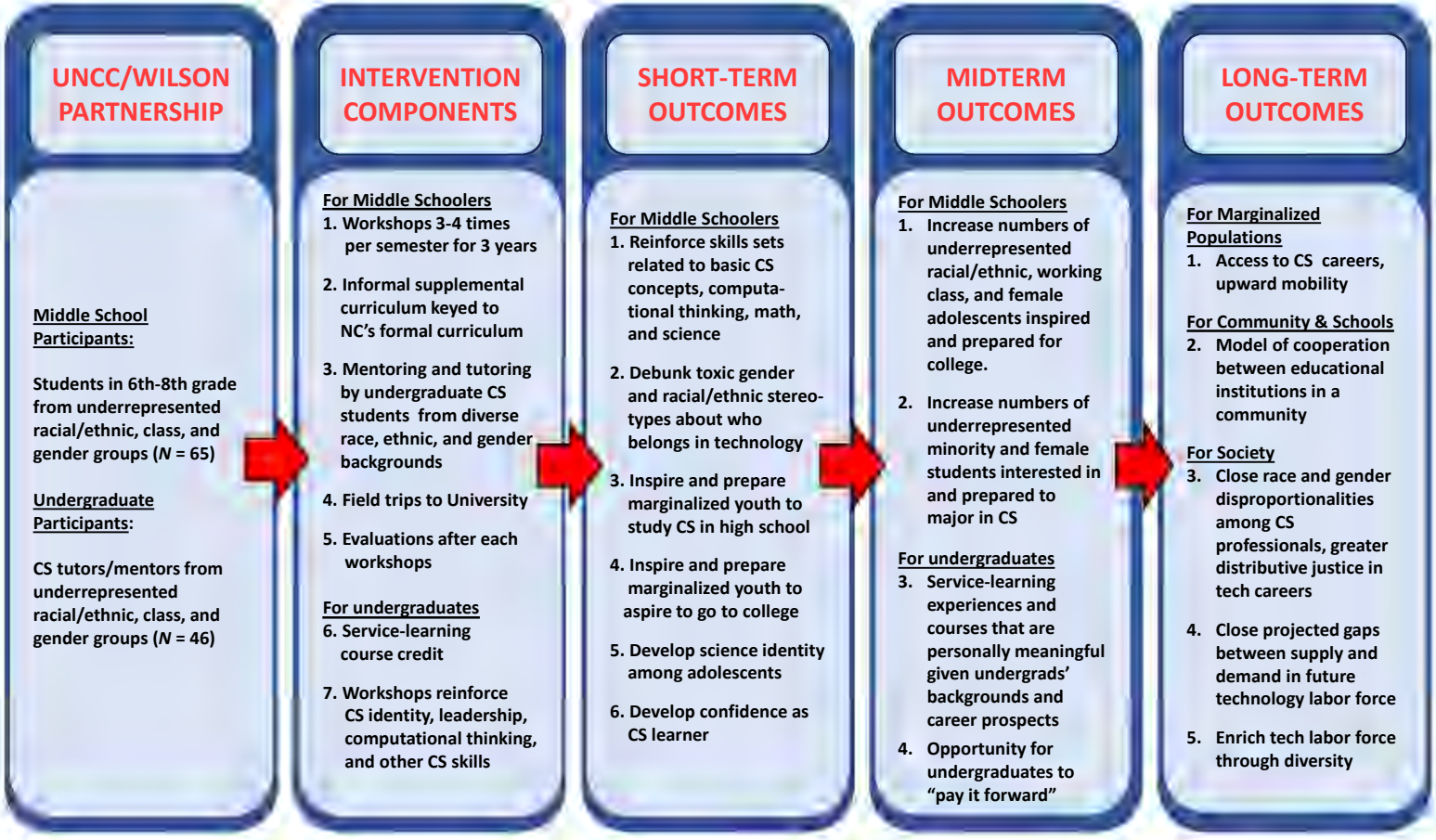
The UNCC/Wilson Partnership: History and Overview

In the spring of 2018, the Dean of the CCI at the UNCC appointed a university-wide committee to make recommendations after reviewing CCI's organization and undergraduate curriculum. This article's faculty authors served on the committee. The resulting White Paper offered several recommendations to advance CCI's goals including organizational, instructional, and curricular reforms, and the development of partnerships with organizations in the Charlotte community (CCI, 2018).

Greater diversity, equity, and inclusion and increasing town–gown collaborations were fitting goals given the weak pipeline between the local public school system and CCI. With close to 150,000 students, Charlotte-Mecklenburg Schools was the eighteenth largest K–12 school district in the nation. However, district graduates did not matriculate to CCI in numbers commensurate with its size and proximity to the university. A 2019 CCI report emailed to staff indicated that only 9% of applicants to the freshman class were graduates of Charlotte-Mecklenburg Schools (M. Perez Quiñones, personal communication with R. A. Mickelson, April 29, 2019). Certainly, many district graduates interested in CS applied to other UNC campuses or to out-of-state schools. Other factors undoubtedly contributed to lower application rates of district graduates to CCI including poverty and racism in the local community and its public schools (Chetty et al., 2014; Mickelson et al., 2015; Nelson et al. 2015).

An additional source of the low matriculation rate was weak secondary school preparation for the pursuit of technology college degrees. Inspiring and preparing first generation, low-income, female, or underrepresented minority youth to pursue CS at college are goals consistent with the White Paper's

Figure 1. UNCC/Wilson Partnership Logic Model



recommendations and matched Wilson STEM Academy's needs for community support (J. Cook, personal communication with R. A. Mickelson, September 2022). The resulting collaboration, the UNCC/Wilson Partnership, sought to engage middle school students in ways that met several shared organizational goals: increasing Wilson students' access and exposure to CS, sparking interest in the field, improving their academic skills in science and mathematics, and increasing their aspirations to pursue postsecondary education in CS. The Partnership also aimed to accomplish several sociocultural goals: undermining negative attitudes and stereotypes about who does or does not belong in technology, enhancing youth's sense of belonging the CS field, and stimulating students' nascent CS identity and confidence as learners. These elements have been previously identified as critical to student engagement and academic success in STEM (Rainey et al., 2018, 2019), and prior research demonstrates that stimulating interest in CS among underserved populations is more effective if done early in students' academic trajectories (Cheryan et al., 2015; Vincent-Ruiz & Schunn, 2018).

Designing and Implementing the UNCC/Wilson Partnership

The UNCC/Wilson Partnership's design team consisted of Wilson's Principal and faculty and several UNC Charlotte faculty with expertise in CS and sociology of education. The intervention supplemented the formal curriculum taught in Wilson's CS classrooms, *Computer Science Discovery* (North Carolina Department of Public Instruction, 2022). The Partnership's informal curriculum was delivered in monthly workshops given by the UNCC undergraduates serving as tutors, mentors, and role models for their younger peers. Designing and implementing the supplemental curriculum was a portion of the academic work product required for UNCC undergraduates enrolled in the service learning course associated with the Partnership.[1]

Wilson is an ideal site for a collaboration with CCI. Wilson is a Charlotte-Mecklenburg School system middle school (Grades 6-8) designated as a partial STEM immersion magnet where all students are required to take introductory CS courses. In 2022, about 90% of its 490 students lived in the Wilson assignment zone, while roughly 10% enrolled via the magnet program. Roughly 96% of Wilson's pupils were racialized minorities, and 98% of them came from low-income families. Less than 20% of Wilson students scored as proficient or above on their NC end-of-grade standardized tests in reading and mathematics (U.S. News and World Report, 2022). These statistics obscure the fact that Wilson was one of a handful of the district's 176 schools that made substantial academic improvement in the 2021–22 academic year (J. Cook, personal communication with R. A. Mickelson, September 2022).

The Intervention: The Supplemental Curriculum and Computational Thinking

The Partnership launched during fall of the 2019–20 academic year with Wilson sixth graders (N = ± 25) chosen by their CS teachers because of their interest in CS. Wilson pupils participated in two field trips to UNCC's campus during the 2019 fall semester. Activities included lunch in UNCC's student union; tours of the CCI classrooms, maker's space lab, sports, and library facilities; and informal CS workshops designed by the UNCC undergraduate tutors with the guidance of their faculty advisor and in consultation with Wilson's CS teachers. The three additional workshops planned for the spring of 2020 were cancelled due to the COVID-19 pandemic.

The UNCC undergraduates and Wilson 6th graders are flanked on the far left by their Principal, Mr. Cook, and on the right by their Advisor, Mr. Sherman (crouching) in Fall 2019. (Note: Wilson's staff obtained signed consent forms, including for photos, from the middle school students' guardians prior to the field trip.)

Initially, all Wilson students were taught the same informal curriculum. After several semesters, they were split into beginners and intermediate groups. New sixth graders learned coding using Scratch (https://scratch.mit.edu/), a simple introductory coding language/visual interface that encourages computational thinking and allows users to create games and animations among other creative projects. A second group, returning seventh and eighth graders, were instructed in Python (https://www.python.org/) and EduBlocks (http://edublocks.org/). Python is an easy-to-learn programming language used by CS

professionals (Dorodchi et al., 2021). Python offers a greater challenge for students compared to the Scratch interface. Both are excellent starting points for young students to become involved with CS as these languages do not require users to handle difficult syntax and concepts in complex environments.

From the onset of the workshops, activities were designed to augment the *Computer Science Discovery* formal curriculum taught in Wilson's CS classrooms. They introduced concepts and techniques inherent in programming languages while exposing computational thinking skills to the Wilson students. Computation thinking skills are built into the supplemental curriculum based on the recommendations of prior studies (Barr & Stephenson, 2011; Dorodchi et al., 2021). Computational thinking is a problem-solving skill set inspired by fundamental computing science principles (Voskoglou & Buckley, 2012). It teaches learners to reformulate complex problems and efficiently solve them using techniques such as abstraction, recursion, and heuristic reasoning. In other words, middle school students learn how to solve problems by analyzing them, decomposing them into a manageable sequence of steps leading to a solution, learning to identify patterns, following algorithms, and detecting and correcting errors. The benefits of incorporating computational thinking into a middle school curriculum can be extensive because the skills are widely applicable to a multitude of other disciplines and life course dilemmas (Wing, 2006).

The Partnership's Pandemic Pause and Reboot

The Partnership endured even though it paused during the Spring of 2020 because of the pandemic closure of in-person teaching and learning at both UNCC and Charlotte-Mecklenburg Schools. It began its second year in the fall of 2020 with a series of virtual workshops on Zoom. Thirteen new Wilson sixth graders joined the continuing students, now seventh graders. In the Partnership's third year (2021–22), incoming sixth graders were added to the continuing seventh and eighth graders. The resumed workshops occurred every 3–4 weeks via Zoom. As the pandemic waned in early spring 2022, the workshops switched to a hybrid format. In-person tutors came to Wilson's campus and presented the material didactically with video illustrations, while Zoom tutors worked one-on-one with Wilson learners. In June 2022, the first cohort of eighth grade Wilson students who participated in the Partnership for three years graduated with plans to enter high school in the fall of 2022.[2] Figure 2 presents the dates, context, and sequence of events in the development and implementation of the UNCC/Wilson Partnership.

Figure 2. Timeline of Key Events in Design and Implementation of the UNCC/Wilson Partnership

21st Century Technology Challenges: 2017–18

- Gender, social class, and racial/ethnic disproportionalities in CS college enrollments and incumbents of current technology occupations.
- Projected short falls in future technology workforce.
- CCI Task Force white paper articulates goal of greater town–gown partnership.
- Internal report identifies very few local high school graduates of local school system matriculate to UNC Charlotte as freshmen computer science majors.
- UNC Charlotte faculty (Cukic, Dorodchi, Mickelson) receive NSF funding for I-PASS Project designed to support underrepresented minority, female, first generation, and low-income undergraduates majoring in computer science.

Partnership Design Year: 2018–19

- I-PASS faculty choose Wilson STEM Academy as site for town–gown collaboration and service learning opportunity for undergraduate I-PASS Scholars.
- Wilson teachers and administration, I-PASS faculty develop objectives, goals, and preliminary contours of Partnership.
- Informal supplemental curricula will be delivered by UNCC tutors during four workshops per semester, will be split between UNCC and Wilson's campuses.

Implementation Year 1: 2019–20

- Partnership launches in Nov., with Nov. and Dec. UNCC campus visits by Wilson students; 25 Grade 6 students participate in first cohort of middle schoolers.
- I-PASS Scholars (n = 16) serve as tutors, mentors, and developers of Partnerships. They enroll in a service learning course each semester they participate as tutors.
- Workshops' informal supplemental curriculum features games, coding, instruction in core concepts, vocabulary, and essentials of computational thinking with one-on-one tutoring/mentoring by UNCC undergraduates.
- Partnership pauses in Spring 2020 due to COVID-19 pandemic in-person school closures.

Implementation Year 2: 2020–21

- Workshops resume via Zoom in Fall 2020 with 13 new sixth graders joining first cohort members who are now seventh graders.
- In Spring 2021, CCI undergraduates interested in Partnership join continuing I-PASS Scholars as additional tutors and mentors via Zoom workshops.
- Informal supplemental curriculum split into Scratch lessons for new incoming sixth graders and Python for more experienced continuing seventh graders.

Implementation Year 3: 2021–22

- Workshops continue in Fall 2021 via Zoom with new cohort of sixth graders joining returning seventh and eighth graders. A mix of I-PASS Scholars and interested CS undergraduates serve as tutors and mentors.

- Memo of Understanding between UNCC and Charlotte-Mecklenburg Schools finalized and signed by organizations' legal counsels after two years of negotiations, permitting UNCC to access anonymized post-workshop survey assessments.
- In spring 2022, the Partnership's activities switched to a hybrid format. In-person tutors and mentors come to Wilson to deliver didactic lessons with new material and lead games, while remote tutors work with middle schoolers via Zoom.
- June 2022, the first cohort of eighth grade students who participated in Partnership for three years graduates from Wilson STEM Academy and readies for high school in the fall.
- Hybrid format workshops commence Year 4 in Fall 2022. New cohort of sixth graders begins Partnership workshops, while seventh and eighth grade participants return.

Implementation Year 4: 2023–24

- National Science Foundation funding for I-PASS ends in Spring 2023.
- Professors Mickelson and Dorodchi take sabbatical leave in Fall 2023.
- The Wilson Partnership continues with tutors using the Partnership's curriculum and materials. However, the Partnership is now part of the UNC Charlotte STARS Computing Scholars program. Through STARS, undergraduate CS majors participate in team-based computing service learning projects in local middle schools.

Assessments

Wilson staff administered confidential post-workshop assessments to Wilson participants after the first workshop and continued to do so through the concluding workshop of the spring 2022 semester. Post-workshop surveys asked pupils about their perceptions of the session, their mentors/tutors, the effects of the workshop on their future college and career aims, educational goals, sense of belonging in CS, and self-concepts as a science learner. All student responses were identified only by a Charlotte-Mecklenburg School student ID number. For three years, these survey data were collected by middle school staff members for Wilson's own purposes and later shared with UNCC researchers after the district granted them permission in 2022.

Research Questions

Based on the social class, racial/ethnic, and gender disproportionalities in CS enrollments; the uneven secondary education provided to many low-income minoritized youth; the literature's identification of likely structural and cultural factors at the core of their frequently less than optimal preparation for the pursuit of CS in college; and the prior literature suggesting the importance of middle school educational experiences for future STEM education, this case study was guided by several questions:

1. Do Wilson students who participated in the Partnership indicate that they are inspired to go to college and major in CS because of the Partnership?
2. Are Wilson student participants more academically prepared to go to college and major in CS than their peers who did not participate in the workshops?
3. Do the tutoring, mentoring, and role modeling by UNCC students influence the Wilson participants' beliefs that people like them belong in CS?
4. In what ways, if any, does participation in tutoring, mentoring, and role modeling of Wilson students affect UNCC undergraduates?
5. Does the UNCC/Wilson Partnership offer a model for community interorganizational collaboration among educational institutions that share common goals?

Methods

To answer the guiding research questions, we drew upon our mixed methods descriptive case study of the Wilson STEM Academy/UNCC Partnership. We utilized a variety of qualitative data sources and some quantitative indicators collected during the Partnership's planning period (academic year [AY] 2018–19) through the first three years of the workshops' implementation (AY 2019–20 through AY 2021–22).

Samples

Wilson STEM Academy Sample

In 2019, about 25 Wilson student participants were selected for the Partnership. Wilson's Principal Jeffrey Cook consciously targeted sixth graders for the first Wilson cohort so that the same students could experience three years of the Partnership's supplemental instruction before they moved on to high school. Subsequent cohorts of sixth graders joined in Fall 2020 and 2021, with preferences given to students who opted into Wilson's magnet program rather than those with residential assignments to Wilson (J. Cook, personal communication with R. A. Mickelson, September 2022).

UNCC/CCI Sample

Initially, all undergraduate tutors were I-PASS Scholars. The acronym I-PASS stood for *Improving the Persistence and Success of Students from Underrepresented Populations in Computer Science* (Mickelson et al., 2022). I-PASS Scholars were undergraduates from low-income families who are either female, from rural communities, or underrepresented racial/ethnic groups. They received scholarships designed to foster the persistence and graduation of underrepresented students in CS. All I-PASS Scholars participated in at least three

of the six semesters of the workshops. Roughly half of the Scholars participated in all six semesters discussed in this case study. All tutors were required to enroll in a service learning course aligned with the Wilson Partnership.

As word spread throughout CCI about the Partnership, undergraduates not affiliated with I-PASS requested permission to participate as Wilson tutors and mentors. Enrollment in the service learning courses opened to all CCI juniors and seniors interested in them in the Partnership's second year. Thirty CS undergraduates not associated with I-PASS, mainly from low-income families and/or marginalized racial/ethnic communities, volunteered as tutors and mentors beginning in the Partnership's fourth semester. Over the Partnership's first three years, 46 undergraduates participated in it. Every semester, undergraduates that volunteered at Wilson were required to enroll in a service learning course aligned with the Wilson Partnership. The service learning courses were team taught by Professor Dorodchi, who concentrated on the CS components of the workshops, and Professor Mickelson, who focused on sociological aspects of the Workshops, including curricular and instructional guidance, and the gender, race/ethnicity, and social class dynamics of the intervention.

Data

This case study employed a variety of qualitative data, including 15 sets of confidential, open-ended surveys collected from Wilson's middle school participants immediately after each workshop, interviews with participants, field notes from observations at workshops or team meetings, and approximately 220 reflective essays written after each workshop by UNCC tutors as assignments in their service learning college course. Reflective essays described the tutors' experiences and were a major part of their academic coursework. In addition to the undergraduate tutors' reflective essays and the Wilson students' post-workshop survey responses, other sources of qualitative data included field notes from planning meetings and in-person observations of workshops. The first author conducted interviews with Wilson staff and teachers and the undergraduate tutors, as well as exit interviews with I-PASS Scholars who graduated with their bachelor of science degrees.

The post-workshop open-ended surveys were designed and administered by Wilson's staff to ascertain the middle school pupils' perceptions of the workshop's influences on their attitudes about college, STEM, CS, and the development of their science identities. All student responses were identified only by a Charlotte-Mecklenburg Schools student ID number. Wilson student data was collected systematically, but only shared with UNCC researchers after the Partnership's Memo of Understand was signed by both educational institutions' legal teams and administrators in 2022.

Analytic Strategies

Coding the Qualitative Raw Data

Members of the research team participated in a multistage process to develop a general coding scheme for all qualitative data that included four interviews conducted with Wilson educators, undergraduates' 220 reflective essays regarding their experiences as tutors in the Partnership, three years of field notes from workshop observations conducted by the first author, 16 exit interviews with graduating I-PASS Scholars—all of whom participated in the workshops between three and eight semesters, and 15 sets of open ended post-workshop assessment responses completed by Wilson students after every workshop (Glaser & Strauss 1967; Krippendorff, 2019; Miles et al., 2020; Rubin & Rubin, 2012).

The analysis method involved an iterative process. Some preliminary codes came from an early screening of data and the existing literature, which were then applied to the data (Timmermans & Tavory, 2012). The research team also used an inductive approach associated with grounded theory to identify new codes as the various data sources were analyzed (Glaser & Strauss, 1967). Research team members then met to discuss the themes present in various elements (interviews, field notes, reflective essays) of the qualitative data. Once members reached agreement regarding the major themes, the research team achieved consensus about how certain data should be coded as the major themes. Next, each of the 220 reflective essays, the 16 exit interviews with I-PASS Scholars and four Wilson educators, and observational field notes were coded by teams of researchers that included the first two authors and several other graduate student coauthors.

The same teams of researchers and graduate students conducted content analyses of pupils' responses to post-workshop assessments. This process revealed patterns across individuals, workshops, and semesters. Researchers compared emergent themes and resolved any discrepancies in coding categories by consensus. Once themes were established, the teams independently coded all students' responses, conducted interrater reliability checks, and in some instances counted the instances where a word or phrase appeared as representations of themes.

Triangulation

Findings generated from the various sources were triangulated across data sources to ensure reliability of interpretations. These included reflective essays, observations, interviews, and survey responses from Wilson. For example, evidence supporting Wilson students' interest in attending college and majoring in CS was drawn from tutors' reflective essays and middle schoolers' answers to post-workshop assessments.

Confidentiality and Reliability Checks

Wilson students' words and responses are not attributed to an identified student. All undergraduates whose insights are quoted are identified by their chosen pseudonym to guarantee their confidentiality. Because of the salience of gender and race to the problematics examined in this study, the description of UNCC tutors' gender and racial/ethnic characteristics reflects their actual identities. Wilson faculty and staff's comments are attributed to them by their actual names and positions. In addition to the UNCC faculty authors, the undergraduate and graduate student co-authors, and Wilson staff members involved in the Partnership had the opportunity to read, clarify, extend, and verify the findings and their interpretations to enhance the manuscript's reliability.

Findings and Discussion

Several themes emerged from the analysis of the qualitative data. The middle school students identified their interest in going to college, learning to code, studying CS, their role and importance of their mentors and tutors, having fun, and future ambitions involving CS careers. Themes that emerged from UNCC undergraduate interviews and reflective essays included opportunities to address the gender, race, and socioeconomic disproportionalities in CS that they experienced before college and as undergraduates; warm supportive attachments among themselves as mentors and their Wilson mentees; the reinforcement of the undergraduates' CS identities; and opportunities for them to "pay it forward"—that is, instead of repaying those who helped them reach their CS goals, they are helping the next generation reach theirs.

Findings for Wilson Students

Inspiring Enthusiasm for Coding

One of the central aims of the workshops was fostering Wilson students' skills and enthusiasm for coding. According to the Wilson post-session assessments that asked students to complete the sentence "This Partnership is important to me because _____", the opportunity to gain coding skills was a key motivation for many middle school participants. Responses to this question referring to coding over the three years of workshops indicate it was the most common answer to why the Partnership was important to them ($N = 88$).

UNCC mentors agreed that the supplemental curriculum's opportunity to teach middle schoolers coding was invaluable for the middle schoolers.

> You can tell when working with them that many of them have never seen anything like this before. Coding is a whole new world for many of

> them, and it is exciting and rewarding to watch them experience it and make connections. (Karl, Black male)

Sparking College and Career Goals

Acting as both ambassadors for UNCC and the college experience, the undergraduate tutors sparked interest in college as an option for Wilson students. Over the course of the workshops, Wilson students became increasingly excited about the idea of going to college and what their future careers could be. A sixth grade male student enthusiastically blurted out during a workshop session, "I am coming to UNCC to study CS. I belong there!"

Twenty-five respondents mentioned going to college when they completed the sentence "this Partnership is important to me because_____" on the post-workshop assessment surveys. Another assessment survey question asked Wilson youth "what, if anything, the session left them wondering about." A middle schooler wrote, "what life in college would be like" for her. Another Wilson student stated the workshops left her wondering "how she could improve her chances of going to college." An I-PASS Scholar described the reactions she witnessed among a few Wilson students with whom she was interacting during a workshop: "I was sitting in the back talking with a few students about what college is like and their faces lit up like a Christmas tree" (Natalie, Black female).

Workshops also inspired the middle school students to think about technology and STEM careers; 35 students answered the post-workshop assessment question "this Partnership is important to me because__" by indicating their career aspirations involved technology. A common response to the open-ended survey question "After today's session with UNCC, I am wondering about_____" pondered how CS intersects with other fields. One student declared, "I love STEM and art, and I will make that my future," while another pupil wrote, "I want to be an architect, but I [now] think about having a minor in computer science."

> The idea is that we are giving middle schoolers a chance to explore CS early on in their life, allowing the students to grasp the very basic ideas…. [Early exposure to CS creates] new opportunities that they did not know existed in the beginning. (Melanie, Asian female)

Undermining Toxic Stereotypes of Computer Scientists

Several Wilson students told their UNCC undergraduate tutors (who also served as mentors) that they were one of the main reasons the middle schoolers were now considering technology careers. "At the end of the [semester's workshops], one girl said that we made her want to be a computer scientist and actually join the field" (Lena, Black female).

Undergraduate mentors were able to connect with the lives of many students that they worked with in the Partnership. Wilson students named specific tutors 27 times in answers to the assessment question "this Partnership is important to me because_____." Most of the UNCC undergraduates shared Wilson students' demographic profiles as members of low-income families and underrepresented ethnic and racial groups. Most stereotypes of computer scientists exclude females, Blacks, Latinos/as, and non-Pacific Rim Asians. Stereotypes influence youth forming notions of who can and cannot participate in a profession. Three-quarters of the tutors were females and/or students of color. This means that a large number of tutor/mentors not only attended college, but also defied pervasive cultural stereotypes of who should or should not become computer scientists. The mere presence of the female and racially/ethnically diverse undergraduate mentors conducting Partnership workshop sessions challenged these norms.

Several Wilson participants' statements reflect the influence of their norm challenging workshop role models from UNCC. One written comment captured many Wilson students' reactions to this aspect of Partnership workshops, "Today's experiences help me believe people <u>like me</u> can be computer scientists" (emphasis in the original). Another Wilson student declared, "if they are capable [of doing CS], then I am too." These sentiments were echoed by the middle schooler who stated, "if that guy can do it [CS], why not me?"

Wilson Students' Learning Curve

This study was not able to obtain pre- and post-intervention assessments of academic outcomes for Wilson student participants and a matched control group of nonparticipants. Without any empirical indicators of academic progress, our research relies on perceptions of the tutors and Wilson CS teachers regarding the academic influences the Partnership had on the middle school students.

UNCC undergraduate tutors and Wilson teachers noted what appeared as a learning curve among the Wilson students over the three years of the Partnership. For example, UNCC tutors described how Wilson students exhibited shyness and were reticent to speak at the beginning of each new semester's series of workshops.

> We used *Kahoots* for both warm-up activities and as a test of knowledge at the end of the session. Students show friendly competition and interest in participating. The good rate of answer accuracy also demonstrates the effectiveness of our lessons and the ability of students to understand conceptual questions related to computational thinking. (Kirsten, White female)

Over time, Wilson students' learning became apparent to their mentors. By the fifth semester of the program UNCC tutors observed that

> As weeks go by, lesson plans seemed to speed up more because the students are beginning to understand what [we ask them to do], and they understand the tasks at hand. The students have been able to stay proactive in making sure they are in sync with those covering the lesson plans as well as taking the proper time to practice things on their own and not wait on further instruction but using their time wisely to explore things. (Quintin, Black male)

> Some students are still more engaged than others…the ones who were engaged seemed to be enjoying this lesson more than the last one. [The] sense of competitiveness between them…only pushes them to try new things even more, which is really great to see. (Tanya, Latino/a nonbinary)

Wilson's CS teachers also noted the workshop participants' academic growth.

> I have had students who, as I'm teaching something in class, um, it triggers a memory or some knowledge that they have gained through your program, and they've even said, "oh, we learned this with the UNC Charlotte group." (Mr. McCormack, Wilson CS teacher)

Nurturing Learners' Self-Confidence and Computer Science Identity

After several workshops, numerous Wilson students recognized that they were capable of following a CS path. The statement "this Partnership is important to me because__" prompted one Wilson student to write, "...because anyone can be a computer scientist as long as you push yourself." Based on five semesters of post-session assessment surveys, we found participation in the Partnership appears to foster Wilson students' insights into their own senses of themselves as learners and budding computer scientists. Emblematic of many answers to post-assessment surveys over the three years of the Partnership, one adolescent articulated the ways that the Partnership affected her self-confidence, "[I am] proud, excited, confident...." Another middle schooler described his nascent science identity development, "I can most definitely be a computer scientist if I put my mind to it and study more about it." A necessary stage in developing a CS identity is the person's acknowledgment that she/he can develop the skills necessary for success (Archer et al., 2010). Students must both believe that they are allowed to be and have the capacity to be a (computer) scientist. Science identity encompasses believing that not only that one can *do* the science, but one can *be* a scientist. The previous comment directly captures this aspect of the middle schooler's development of his CS identity.

Interviews with Wilson's CS teachers contrasted the classroom behaviors of the Workshop participants with the other students in their classroom. When asked if the workshop participants are more self-confident learners, a faculty member replied,

> I would say yes…in terms of self-confidence as a learner, they're more likely to, if they're struggling with something, keep at it themselves, it, as opposed to shutting down or, um, calling for help. I have a lot of students who'll take one look at it and just raise [their hand and say] "I need help, I can't do this." But those students who are in the program, many of them will at least attempt it a couple of times and really live in that struggle a little bit, um, trying to, trying to solve whatever the problem is on their own as opposed to relying on someone else to kind of walk them through it. (Ms. Johnson, Wilson CS teacher)

Some Wilson participants' previous self-perceptions of their capabilities meant they shied away from considering CS as an academic pursuit. As Wilson students moved through the workshops, however, they learned of the ways that their mentors also struggled and had learned from their mistakes. As the knowledge that their role models' learning included overcoming challenges, Wilson students' self-confidence in their own abilities to succeed in CS grew.

> [The Wilson student] would say things like "Oh I'm so sorry, I'm not really good at this" or "I'm sorry, I can never understand this," and I would reassure her that it is okay to make mistakes, and all of us are here to learn, including me. In the end, she started saying things that really made me feel proud of our work so far. She was saying statements like "I like doing this. I think I should be a computer scientist" and "I think I should go to [UNCC] and study CS." (Zinobia, Asian female)

An Unexpected Finding: Workshops as a Safe Space for Academic Efforts

The Wilson teacher interviews revealed an unanticipated finding regarding the contrast between participants' behaviors in the workshops and the same students' behaviors in their regular CS classrooms. The teachers expressed surprise to learn that in the workshops Wilson pupils exhibited enthusiasm for CS. Participants paid attention to their tutors and, amidst their chatter, waved their hands in the air while shouting out answers to queries, competed to win in *Kahoot*, and enthusiastically engaged in the workshops' various activities. According to both teachers, these behaviors starkly contrasted with the distracted demeanor, flat or blasé affect, and undistinguished classwork the same students displayed in their CS classrooms.

Wilson's CS teachers described the distribution of students in a typical classroom. Roughly 25% of their students are high flyers who "zoom through the

coding [and] help others." They get their work done, turn in their assignments, and are very interested in excelling academically. High flyers' behavior was not the norm—even among Partnership students. Instead, workshop participants "…get the work done, but they don't seem like they're interested in going into the field. They're not submitting assignments and things like that. They're completing it. They're not turning it in" (Ms. Johnson, Wilson CS teacher). When asked by the interviewer what, if anything, might account for this apparent contradiction between positive affect and academic effort among workshop participants and suboptimal classroom behaviors among the same individuals, teachers focused on negative peer pressure.[3]

> They're pressured. It's still going on that if you're smart, you're a nerd, and then that's a negative thing. And then they don't want to try to learn because the other ones are trying to say, look, we don't want to do this. (Mr. McCormack, Wilson CS teacher)

> And they talk negative about school all the time, "But I'm not going to do this. It's not the cool thing. It's not the cool thing to do." So that was, that's what gets them off track. (Ms. Johnson, Wilson CS teacher)

We have no observational data regarding the extent of workshop participants' contrasting classroom and workshop behaviors, nor can we investigate the underlying dynamics of those who engage in it. But against the backdrop of well-established norms against visible academic engagement captured throughout the literature about underrepresented minority youth (Fryer & Torrelli, 2010; Harris, 2011; Horvat & O'Conner, 2006; Ogbu, 2004; Tyson, 2002.), the CS teachers' hypothesis is plausible. Unlike in the classroom settings, in the workshops students could be enthusiastic and engaged. All the students in the workshops were interested in technology and coding, so no one had to deal with peer pressure to be "cool" by feigning disinterest in CS or academic effort. The Wilson Partnership workshops offered a safe haven from negative peer pressure. As one middle schooler explained, "This Partnership program is important to me because I can be myself." Another eighth grader wrote, "The members [of the workshop class] are cool, and I don't like being in class, and its better in [here] and I learn a lot."

Summary of Findings for UNCC students

Addressing Social Inequities Through the Mentorship

Many Wilson students had limited early exposure to coding, few of their families had home computers available for children to use, and their residential internet service was compromised or absent.[4] UNCC undergraduates' interest in providing CS skills instruction and encouragement to Wilson students

was informed by their own understanding of what life is like as a member of a low-income family and/or socially marginalized youth seeking to join the CS community. Many I-PASS Scholars' experiences as working class females and/or members of underserved racial/ethnic groups sensitized them to Wilson scholars' challenges and limited opportunities in CS.

Wilson students at times experienced aspects of the digital divide rooted in the socioeconomic, gender, and racial/ethnic inequities in Charlotte and the city's school system (Chetty et al., 2014). One undergraduate, first in his family to go to college, attended a high poverty local middle school with very limited curricula or extracurriculars devoted to technology. He and others observed:

> I never heard of coding until I got to high school. Even then, I didn't think much of it. [Because of the Partnership, Wilson students] get to learn at an early age and get to know what coding is. (Raymond, Southeast Asian male)

> When I asked if they think they could create software programs or do simple coding to get a certain result from the computer, they replied "no." They couldn't even think about how they could reach the desired outputs of software by coding. They could vision the end result, such as using games and computers, but they couldn't vision the process and how the programmer/developer got the game or computer to do what it does. (Arlene, Black female)

> Many Wilson Scholars may not have such support at home, in school, or in their communities. Therefore, this supplementation [workshop] is very important to the fueling of their scientific interests. The students of Wilson…are exemplary examples of talented individuals that are swept under the rug by the tech industry. They [come from] underrepresented [groups], mainly Blacks and females. (Kirsten, White female)

> The girls that I had in my group were also all minorities in multiple aspects such as gender and race, similar to myself. They might experience similar hardships that I had experienced when they eventually enter the field….Therefore, I made sure to bring awareness to the fact that we were all part of the minority in some aspect, one way or another; however, this did not mean that we were lesser than others who were not in the minority, it just meant that we might have to work harder to maintain ourselves in our profession. (Beatrice, Pacific Islander female)

Attachment Between Mentors and Mentees

Over the course of the three years the Partnership operated, the undergraduate mentors supported the Wilson students and received a great deal in

return. Given the events of the past few years (the pandemic and its sequela, the murder of George Floyd and the ensuing civil protests, personal and family crises), it is not surprising that some undergraduate tutors considered the positive feedback from Wilson students to be emotionally sustaining. They became attached to their mentees. Finding that they had an impact on Wilson youth motivated the UNCC undergraduates to keep working in the Partnership. As one undergraduate said, "the outpouring of support from many of the [Wilson students] was very encouraging." Another said,

> I love seeing their excitement and engagement with us, especially when they recognized our names and would occasionally mention us in the chat room.[5] I felt like just by recognizing our names alone, we have made an impact in their lives. If they can remember our names then I am positive that they remember all the things that we have done together throughout the semester, and I wish for the memories and the knowledge to stick with them for a long time. (Zinobia, Asian female)

Tutoring Wilson Youth Reinforced UNCC Undergraduates' CS Identities

UNCC tutors' own CS identity solidified as undergraduate CS learners developed their role as a CS tutor and mentor for Wilson youth. They found working to identify and address the obstacles that Wilson students face also helped them to appreciate how they developed their own CS identity. The connections between the two groups of students, especially the ways the middle school youth's STEM pathways mirrored the journeys of the undergraduate mentors, reinforced the college students' own CS identity. This occurred through not only their identification with their younger counterparts, but also through the process of being a mentor.

> I've learned a lot from the Wilson [students] just by talking to them about their interests. If research like this [Wilson Partnership] was around when I was in middle school, I think I would've found computer science earlier and maybe known for a fact what I wanted to do before coming to college. (Lena, Black female)

> [The Wilson Project] helps me as a developing computer scientist better recognize the various applications of my growing skillset. I find it quite empowering to be able to utilize my problem-solving and computational thinking abilities in various real-work and academic scenarios. This allows me to expand my personal identification from beyond a "computer scientist" to someone who is also a good problem solver, logical thinker, and methodical worker as a result of my computer science education. (Cathleen, White female)

One of the UNCC undergraduates, now employed as a computer scientist at a major corporation, described her involvement with the Wilson Partnership,

> Honestly, when I went through the [job] interviews, that's all I talked about, and then the [interviewer] was like, "Oh, you're actually teaching these kids." Well, she was impressed. She was like, "Oh, that's really cool." [By] just asking the question, just kind of like asking about the [Partnership] program, you know, [she was] checking my skills and stuff. (Zinobia, Asian female)

Paying It Forward

Many UNCC undergraduate tutors' reflective essays articulated a need for them to give back to the community from which they came. The Partnership actually gave the undergraduates a chance to pay it forward; that is, instead of looking backward to repay their own mentors and teachers, they look forward and assisted the next generation of youth like themselves. For some this took the form of efforts to create an atmosphere that would allow for hometown peers to follow in their footsteps to college and major in CS. For others, it was desire to benefit their community. Several I-PASS Scholars aspired to teach CS in secondary school but demurred when they discovered how low starting teaching salaries are in North Carolina. For I-PASS students and the other CCI tutors, the Partnership offered an opportunity to pay it forward. The middle school cohort was seen as a potential part of the CS community more broadly and worthy of an investment of their time, caring, and intellectual resources.

> I enjoy mentoring the Wilson middle students because it provides me a chance to give back to the community and be a positive force for change. I have always planned on being able to tutor students and help build interest in CS in the future; however, the problem I would always encounter is "what platform am I gonna use to tutor the kids." Luckily the I-PASS program gave me a platform to help give back, and being able to give back has really made me glad that I am a computer science student. (Peter, Black male)

> Being able to teach these Wilson students felt like it was my way of giving back to the computer science community after so many others had helped me to such a great extent to develop my identity as a female programmer so many years ago. (Alexis, Asian female)

Conclusions

The findings allow us to begin to answer our guiding research questions. The first one asks if the Partnership inspired Wilson students to go to college

and major in CS. Responses to the Wilson post-workshop assessments suggest that many Wilson students began to develop CS identities, a sense of belonging in CS, and greater self-confidence as a CS learner. Their desire to learn to code, go to college, and major in CS were also themes in the data from Wilson pupils and UNCC mentors. These results suggest workshops influenced students' growth in these areas.

The second question asks if the Partnership academically prepared Wilson pupils for college and CS majors. The nature of this study's research design did not permit us to collect objective indicators (such as high school math and science course enrollment, grades, SAT scores) on this question. Because of the necessity for student confidentiality, high residential mobility among low-income families, the three-year lag between graduating from Wilson and possible matriculation to college, and the bureaucratic difficulties of obtaining student data from the district, it was not possible to answer the second question with empirical indicators. Instead, we turned to the perceptions of the tutors and CS teachers for a tentative answer. They noted that many of students exhibited behaviors consistent with academic growth and that if the behaviors were to continue during high school, Wilson students would be more prepared for college and a CS major than comparable peers who did not participate in the workshops. However, this answer is merely speculative.

The effects of mentors as role models formed the third question. The old chestnut of wisdom comes to mind: "You can't be it, if you can't see it." Both Wilson and UNCC students confirmed that the Partnership met its goals of exposing Wilson youth to role models from demographic populations still marginalized in CS, people whose backgrounds are similar to their own. Several pupils mentioned the importance of specific mentors. Wilson pupils explicitly stated that after participating in the Partnership workshops with their tutors, they are now thinking about going to college and majoring in CS. One Wilson middle schooler's comment summarized the answer to the question, "Today's experiences help me believe people like me can be computer scientists." The findings from the interviews we conducted with mentors, their reflective essays, and the responses to the post-workshop surveys suggest that the diverse mentors provided role models who debunked toxic stereotypes of who can be a computer scientist. Importantly, the positive effects of the role models were not only because the tutors shared racial and gender identities with the Wilson Scholars. The role models were also the middle schoolers' tutors and mentors who, over the course of six semesters, demonstrated that they cared about their young Wilson peers. The mentors, many of whom returned year after year, created an authentic relationship with the mentees. This goes beyond simply sharing a racial or gender identity with the middle schoolers. The

undergraduates built human connections with their mentees while they undermined stereotypes that people like them did not belong in CS.

The study's fourth question concerned the effects the Partnership had on the UNCC undergraduates. Did they perceive that involvement in the Partnership affected their sense of belonging in CS, their own career goals, and their capacity to shape social justice in their own communities and the technology field? The 220 reflective essays collected over three years from all undergraduate tutors and the exit interviews with every I-PASS graduate strongly suggest that for most undergraduates, experiences at Wilson positively shaped their CS identities and sense of belonging in the discipline, reinforced important academic and social skill sets, and in some cases gave them the opportunity to address the social and educational inequities that they experienced themselves in their own journeys to CS by paying it forward at Wilson.

The final question asked if the Partnership offers a model for community interorganizational collaborations among educational institutions that share certain common goals. The tentative answer is yes. The Partnership was tailored to Wilson's particular student population and the educators' requests for assistance with their CS students. Any successful collaboration must be crafted to address a community's needs and the educational institutions' capacities. While no case study is generalizable, the findings suggest that the components and implementation of the Partnership as presented in the logic model (Figure 1) offer a potential roadmap for future cross-institutional collaborations in communities seeking to address the gender, racial/ethnic, and socioeconomic gaps in their schools' STEM courses to help diversify the prospective technology labor force.

Limitations

In addition to the absence of external validity of any case study, this study's findings do not have empirical indicators of the efficacy of the intervention. First, it lacks baseline measures of Wilson participants' beliefs about going to college, interest in STEM and CS, or norms about who does or does not belong in the field. Findings only report possible changes in these beliefs based on district and university statistics, Wilson students' post-workshop assessments, and the impressions of CS teachers and UNCC undergraduate tutors involved in the workshops. Second, findings are limited by the absence of empirical short-term outcome data about participants' academic performance in their middle school CS classes or their actual enrollment in high school CS courses or other STEM subjects. Third, we do not have long-term outcome indicators about college and CS major compared with their otherwise similar peers who did not participate in the workshops. Without these empirical indicators, our

findings reflect only the aspirations of the Wilson students themselves and the impressions of their CS teachers and undergraduate tutors. A fourth limitation concerns the self-selection of the Wilson students and UNCC undergraduates involved in the Partnership. The characteristics of the self-selected samples raise issues of selection bias and further preclude drawing definitive conclusions from any findings.

Importance

The many limitations notwithstanding, the study's findings suggest a potential model for a collaborative intervention to address the technology challenges many of our schools face. The workshops appear to spark marginalized middle school youth's interest in going to college, in coding, and in CS careers. The workshop experiences appear to augment development of CS identities and build the self-confidence of the middle school learners. These tentative outcomes are important because prior research indicates science identities are central to success in all STEM fields (Cohen et al., 2021; Johnson, 2020). The case study illustrates the potential importance of exposure of young adolescents to successful role models for motivating them to consider technology careers despite computer scientist stereotypes that exclude them. At the same time, workshops appeared to reinforce the CS skill sets of the undergraduate tutors and permitted them to engage in service learning that was meaningful to them. Finally, the Partnership offers a model for a community collaboration to achieve common goals.

This study began at the intersection of several trends that coalesced during the last decade, the structural roots of which were exacerbated by the COVID-19 pandemic. The trends include the growth of the importance of technology in all aspects of public and private life, the likely disjuncture between projected labor force needs and the number of adults trained in the sciences, the numbers of youth entering college with the requisite interests and preparation for CS majors, and the untapped talent and potential of youth who do not have access to preparation or believe they do not belong in CS. Additionally, the persistence of gender and ethnic/racial underrepresentation in the field has implications for the maintenance and reproduction of social and economic inequality. The findings from this case study are consistent with prior research on the importance of inspiring and preparing adolescents for STEM learning during middle school. Results also support the significance of informal active learning for reinforcing the formal curricula and fostering development of adolescents' CS identities. Our findings that the UNCC tutors helped undermine toxic gender and race/ethnic stereotypes about CS confirms the existing literature pointing to the importance of consistency, reliability, and authenticity of

mentors who developed caring relationships with their mentees. The concept of paying it forward is not new. However, it does not appear in the literature on low-income undergraduates of color in CS service learning courses. The Wilson Partnership offered UNCC undergraduates an opportunity to meet their service learning requirements while working to create a more inclusive tech community.

This case study offers a model of a focused intervention—the creation and implementation of a community collaboration between a university and a public middle school that begins to address both the weaker inspiration and preparation among low-income middle schoolers who are females and/or underserved minoritized youth and many of the exclusionary stereotypes at the heart of the technology challenges that face the nation. The UNCC/Wilson Partnership itself cannot solve the dilemmas that contribute to the low numbers of inspired and prepared undergraduates from these backgrounds, nor can the Partnership eliminate the persistent disproportionalities among those who enroll as technology majors once they arrive on a college campus. Fully addressing these challenges must await systemic institutional reforms that tackle the structural foundations of these long-standing social problems.

Endnotes

[1]The following URL links to the Spring 2022 Scratch and Python supplemental curricula lesson plans for the UNCC/Wilson Partnership: http://tinyurl.com/CTMiddleSchool. Lesson plans were revised each semester as needed.

[2]Data collected from the Partnership's fourth year (2022–23) are not included in this article.

[3]We are well aware of the voluminous and contentious literature about the anti-academic peer pressure some underrepresented minority youth experience, but engaging it is beyond the scope of this article.

[4]This manifestation of the class/race digital divide at Wilson was eased by the Charlotte-Mecklenburg school system's provision of laptops to all students and of hotspots at libraries in communities with poor internet access.

[5]The tutor inadvertently misspoke when she referred to a workshop's Zoom session chats among students and tutors as a chat room.

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