DPS Professional Learning Communities: Fostering Equity and 21st Century Skills in CS Education

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Abstract: Through quality Computer Science (CS) high school courses, North Carolina residents, especially women and people of color, can be better equipped to take advantage of the state's growing tech jobs. However, on the state level, the North Carolina Department of Public Instruction has not instituted meaningful accountability and support measures for CS high school teachers. Therefore, Durham Public Schools (DPS) must create Professional Learning Communities to support CS high school teachers in utilizing CS to promote greater equity and 21st skills.

BACKGROUND

NC Tech Diversity

NC has become the southern epicenter for technological innovation and research. In the past five years, NC tech jobs have grown by 17.4%, compared to the national average of 7.7% (NC Tech Association, 2018). NC is projected to maintain its higher than national average growth of tech jobs through the next ten years (NC Tech Association, 2018). In this tremendous growth, NC has left women and people of color behind. Only 36.3% of the NC tech sector is composed of women, and NC ranks below the national average for minority tech workers to state minority population ratio (NC Tech Association, 2018).

NC must recruit more women and people of color to tech careers for two reasons: 1) people of color and women obtain greater economic independence and mobility via high-paying tech jobs 2) companies and universities gain a competitive advantage through diverse talent. First, NC tech occupations have median hourly earnings of $41 which is almost triple the state's median hourly wage of $17 (NC Tech Association, 2018). Women and people of color are thus able to earn more money through high-paying tech jobs which is especially important given that NC women earn 82 cents on the dollar compared with men and black workers earn $5 less on per hour than their white counterparts (Think NC First, 2018).

Second, while we, as teachers, workers, and citizens, recognize the value of diverse individuals within our lives, research reinforces that there is a link between diversity and company financial performance. A McKinsey report of over 1,000 companies across 12 countries emphasized the profitability of diversity in the workplace. Gender diversity on executive teams had a positive correlation with out-performing peers in profitability and value creation (McKinsey, 2018). Likewise, executive teams with greater culturally and ethnically

diverse team members were 33% more likely to be more profitable than their peers (McKinsey, 2018). Additional research by Credit Suisse and researchers from Northwestern, University of Texas of Dallas, Massachusetts Institute of Technology, Texas A&M University, and other institutions all confirm the return on profit of a more diverse workforce (Rock & Grant, 2016).

Greater diversity in NC tech is beneficial to people of color and women as well companies/universities. In NC, where there are 18,000 unfilled computing jobs yet fewer than 6,000 students in CS courses, the problem is not a dearth of opportunities (North Carolina State Board of Education Department of Public Instruction, 2018). The problem is the lack of students, especially women and people of color, interested in CS during their educational careers.

High School Computer Science

Women lose interest in CS later in their educational career. Preschool and elementary female students have positive attitudes towards computers (Cohoon & Aspray, 2017). However, as they progress through their educational career, female students lose interest and self-efficacy in CS as male students are given more time and attention by instructors and take up more computing time (Yadav, Aman & Gretter, Sarah & Good, Jon., 2017). It is then no surprise that the percentage of females in CS decrease dramatically from early student years to working years (Cohoon, Aspray, 2017). Additionally, although black and Hispanic students were 1.5 to 1.7 times more likely to be interested in learning CS, they had less access to CS classes in schools and laptops at home than their white peers (Google, 2017).

This research focuses on high school CS education, because women lose interest later in their educational careers, and, due to the lack of NC middle school CS classes, people of color lag behind access to CS courses in high school.

Most importantly, the research focuses on high school CS education, because exposure to CS during this time is extremely pivotal for pursuing a career in tech. Most tech jobs recruit graduates with CS majors, and such graduates choose to major in CS due to their exposure in high school (Code.org, 2014). Research shows that students who learn CS in high school are six times more likely to major in CS in college, with women ten times more likely (Code.org, 2014). In NC, of all AP CS exams taken, only 27% were taken by female students and 6% and 7% by, respectively, Latino and Black students (Code.org, 2014). The low participation in CS by women and people of color must be addressed in high school as this period proves imperative to majoring in CS and later working in tech.

Focus on Durham Public Schools

The research focuses exclusively on Durham Public Schools (DPS) high school CS education. While Durham is only a percentage point different in female persons than NC, Durham is more racially diverse than NC with a population made up of 37.8% African Americans and 13.7% Latinx folks, as compared to North Carolina's 22.2% and 9.5%, respectively (City of Durham, 2016). Differences and similarities of the population demographics of Durham and NC must be considered when adapting recommendations to other local NC jurisdictions.

METHODS

Of the 16 total Durham Public Schools' high schools, only 7 of those schools offer a CS course. 43.8% of DPS high schools offer CS which is higher than the national average of 35% of high schools that offer CS (Durham Public Schools, 2017). At those 7 schools, I reached out to

CS teachers directly or to administrators to connect me with CS teachers. I was able to interview one teacher from each of four schools (Riverside, Hillside, New Tech, Jordan), gaining insight from 57.1% of schools which offer CS in DPS.

All four schools have a AP Computer Science, AP Computer Science Principles, and Introduction to Computer Science course (Durham Public Schools, 2017). Riverside was the only school that did not offer the Introduction to Computer Science course. Hillside, Jordan, and Riverside are three of four comprehensive DPS high schools. New Tech is a magnet and specialty high school. New Tech differs from comprehensive high schools in that it has a smaller total population of 400 students (as compared to 1,000+ students across the three other schools) and is an affiliate of the New Tech Network, which requires students to complete honors level courses, community service, senior project, and digital portfolio.

Regarding student demographics, Hillside and New Tech are the most diverse of the four schools. Hillside has 76.5% Black students and 17.7% Hispanic students (Durham Public Schools, 2017). Housed near Hillside, New Tech has 80.4% Black students and 13.1% Hispanic students (Durham Public Schools, 2017). The two remaining schools, Jordan and Riverside, are less diverse. Jordan is much less diverse with 37.9% Black students and 25.8% Hispanic students (Durham Public Schools, 2017). Riverside follows a similar trend with 39.6% and 32.3% Black and Hispanic students, respectively (Durham Public Schools, 2017). All schools have similar percentages of females as New Tech is 38.9% female, Hillside is 49.9% female, Jordan is 47.5% female, and Riverside is 45.4% female (Durham Public Schools, 2017).

These data come from semi-structured, open ended interviews with four teachers: Teacher Riley (Riverside), Teacher Dakota (Hillside), Teacher Alex (New Tech), and Teacher Ford (Jordan). Teachers interviewed all currently teach a CS course, and their names were

changed to protect confidentiality. Interviews were conducted from October 2018 to December 2018 via phone. All interviews took place during normal business hours from 8am to 5pm on weekdays. They typically lasted thirty to forty-five minutes. Teachers were informed that they were not required to participate, could skip a question at any time, and would not be compensated for their time. No participants chose to end the interview prematurely.

The interview questions were organized by four basic categories: class demographics, teaching interest/background, test performance, and recommendations. The interview questions were constructed with bi-weekly mentorship from a professional at RTI International and focus on the individual experiences of each teacher.

RESULTS

While the research focused on teacher experiences and observations within the classroom, findings about district and state CS education naturally emerged from the teacher interviews. To follow-up, I researched independently and interviewed an individual from The Friday Institute for Educational Innovation to understand more of the themes from teacher interviews.

1. State Level

Most CS courses are CTE courses

The North Carolina Board Department of Public Instruction (DPI) has developed Career and Technical Education Pathway (CTE) that include 16 Career Clusters such as "Business Management and Administration" and "Technology Engineering and Design Education." CTE courses are often elective courses that students can, but are not required to, take. CS

courses, with the exception of Advanced Placement (AP) CS courses, are categorized as CTE.

Although CS is categorized as a CTE course, there has been little efforts on the state level to account for NC CS participation, achievement, and strategy. Additionally, DPI has not set forth a position within DPI that focuses on exclusively CS initiatives, recruited and trained CS teachers, and disseminated CS educational materials to parents, students, and educators (North Carolina Department of Public Instruction, 2018). As of date, DPI has made little effort to track and support CS high school education across NC.

Lack of Curriculum Guidance

There are no K-12 CS content standards in NC (North Carolina Department of Public Instruction, 2018). Content standards are usually included in the NC Standard Course of Study and serve to guide the creation of curriculum materials by NC. Because curriculum materials should align with content standards, DPI currently offers no curriculum materials to help CS teachers create their own curriculum (North Carolina Department of Public Instruction, 2018).

Additionally, DPI has not delineated a course sequence for CS in high school that supports students to pursue CS in college or in the professional setting (North Carolina Department of Public Instruction, 2018). Teachers interviewed utilized open source curriculum from Microsoft, Project Lead the Way, Code Academy, and other resources due to the lack of state CS content and curriculum support.

2. District Level

No CS Professional Learning Communities

DPS Professional Learning Communities (PLC) are communities of teachers within the same subject area that convene to share best practices, curriculum ideas, and personal experiences. Because teachers can give and receive support from one another through PLC's, teachers are better prepared to foster student learning and development. Teachers have stated that there is no CS PLC within DPS.

Given the lack of instruction and guidance about CS education on the state level, CS teachers in DPS face additional difficulties and responsibilities from teachers in other CTE courses. Teacher Alex emphasized the need for more teacher support within the district due to this lack of PLC for CS. Alex also stated the importance of a CS teacher community in addressing many of the specific needs of CS teachers relating to equipment funding, curriculum adaptation, and varied student learning paces.

Lack of Appropriate Equipment

Teacher Riley mentioned that DPS support for CS, if any, is not coming into their class. Teacher Riley expressed that this is particularly problematic for CS classrooms, because students are utilizing outdated machines that does not support the teaching and learning of CS. While Teacher Dakota received monetary support for micro:bit equipment, small LED lights that can be programmed, they had to go out of their way to request funding. There appears to be no formal channel for CS teachers to systematically request funding for equipment to enhance their teaching as well as for an overhaul of outdated equipment.

3. Classroom Level

Introductory Classes More Racially Diverse

Teachers perceive introductory classes to be more racially diverse. Teacher Riley stated that ~81% of their introductory class were Black and Hispanic, as compared to ~10% of the AP

Computer Science Principles (CSP) course who are Black and Hispanic. Teacher Dakota shared a similar sentiment as an overwhelming majority of their class consists of Black or Hispanic students as the class is representative of the 99% student of color population at the school. Additionally, Teacher Ford, who teaches the Computer Science Essential course which is adapted from Project Lead the Way, shared that ~50% of the classroom are students of color. Although there is a lower percentage of students in Teacher Ford's classroom than Teacher Riley's introductory CS class, Teacher Ford's classroom reflects the student demographics of their school. Teacher Alex's classroom consists of ~80% of African American students and has only about ~5% white students. Teacher Alex's introductory classroom is very representative of its school.

Because students are placed into introductory CS courses due to limited electives or scheduling conflicts, the CS introductory courses are often reflective of the schools' diverse student populations. Counselors and administrators are more comfortable placing students into introductory CS courses as an elective, because they are less academically rigorous and require less time commitment than AP CS courses. Across all four schools, teachers have stated that the introductory courses are fairly reflective of the school's student population.

While the high percentage of DPS students of color in introductory CS classes is encouraging, the percentage of students of color across AP CS classes in the nation, like in DPS, is disappointing. In 2016, only 15% of AP CS exam takers were students of color which increased to 20% in 2017 (Alba, 2017). Supporting this trend, DPS teachers have emphasized that introductory CS courses are more racially diverse than the AP CS courses.

To understand this gap, I gathered feedback from teachers as to why this gap exists. A common theme that emerged is students' perception that introductory courses are more

approachable than AP CS courses. The introductory courses are advertised with the objective of discovering the possibilities with CS and seek to build feelings of CS self-efficacy in students. AP CS courses are more focused on developing and honing technical skills as students are measured by their CS and computational thinking (CT) abilities on the AP CS test. Introductory courses are especially important for engaging students of color, because such students perceive very few Hispanic or Black computer scientists in TV or movies (Google, 2017). These students are more likely to see White or Asian men engaged in computer science (Google, 2017).

Because introductory courses are taken by high proportion of DPS students of color, introductory courses must be more intentional in building interest and self-efficacy in students of color. In accomplishing these objectives, students of color are more likely to persist into AP CS courses. Introductory courses are currently an underutilized pathway toward more sustained and deeper CS engagement.

Lower Participation by Women

Given the fairly equal female and male student populations across all four schools, there are strikingly fewer female students than male students in CS classes across three of the four schools. Teacher Riley reported that of the fifteen students in the CS class, there were four female students (a 26% female rate). Similarly, Ford estimated that their classroom has about 20% female students. Even more alarming, Dakota's class consists of all male students. An anomaly is Teacher Alex's classroom where there is an equal representation of female and male. It is important to note that, because Teacher Alex teaches in a magnet school where students have self-selected into STEM-focused school and where there are few elective courses, more women were likely to participate in CS courses. However, Teacher Riley, Ford, and Dakota's

alarmingly low levels of female student participation suggests that the recruitment of female students in CS courses are an issue.

This finding is consistent with nationwide research on females in CS classes. In secondary school, only 18.6% of AP CS test-takers were female-identified (Google, 2017). The teachers suggested that many female students do not believe that CS is for them. One teacher elaborates that "a lot of CS is connected to video games, and [because]…boys are more interested in video games," more male students elect into CS classes. How CS is taught may contribute to findings that, across the U.S., female students are less interested (16% vs 34%) and less confident that they could learn CS (48% vs. 65%) (Google, 2017). Synthesizing teacher interviews and existing research, this lesser interest and confidence, rooted in the perceptions surrounding CS, could keep female students from participating in CS in DPS.

Apart from internal motivations, male students are more likely to be told by a parent that they would be good at CS (46% vs. 27%) (Google, 2017). This pressure extends past the home and into the classroom as males are 39% likely to be told by a teacher that they are good at CS as compared to 26% for female students (Google, 2017). On top of the internal barriers based on perception of CS, female students also face external barriers in active support and encouragement by adult figures. The combination of both internal and external barriers to participation is pivotal in explaining the low participation in females in CS courses, both in DPS and across the nation.

Female students must be actively recruited into CS courses. Since counselors in DPS often introduce and place students into elective courses, counselors must be more intentional and deliberate in recruiting female students in CS classes. Unlike students of color who do not elect to continue with more rigorous CS classes, female students are not recruited into CS from the

beginning. Retention of students of color and recruitment of female students must be improved within DPS.

CONCLUSION:

NC citizens, especially women and people of color, can benefit greatly from the high wages and high supply of tech jobs. However, in order to be not only qualified but also interested in such positions, NC citizens must have exposure to CS earlier in their educational career, with high school CS courses proving to be an especially pivotal time. However, both the North Carolina Department of Public Instruction and Durham Public School district have not yet taken direct and meaningful action to prioritize CS education, leading to adverse effects for student learning within classrooms across Durham.

While DPI's recent report to the North Carolina General Assembly to Expand Computer Science Opportunities to All Students in North Carolina K-12 Schools establishes a long-term plan for CS education in NC, many DPS students will graduate high school without the interest or skills to pursue a CS-related career.

Due to low accountability and oversight measures for CS education in NC, CS teachers face additional challenges. They must create their own curriculum with no guidance from the state and find funding sources for equipment needs as well as teach with outdated equipment. All teachers interviewed emphasized that a DPS CS teacher community is imperative to addressing their specific challenges. Therefore, I recommend DPSsa establish a PLC for CS teachers to better engage all DPS students in CS courses. While the PLC should focus on the curriculum and equipment challenges, I outline Recommendation #1 & #2 to focus on equity by, respectively, recruiting more women into introductory classes and retaining more students of color in AP CS

classes. Recommendation #3 focuses on harnessing CS to better foster skills for all students to participate fully in 21st society.

PLC Recommendation 1: Recruiting women into introductory CS classes

Students of color participate in DPS introductory CS courses at much higher rates than the national average. Teachers often mentioned that the introductory classes are extremely representative of the schools' diverse student population, with more advanced AP CS classes less so. As suggested by the teacher interviews, this may be due to two factors: 1) students are placed into an CS by counselors or administrators 2) students are less intimidated by an introductory CS course. While these factors may correlate to the increased student of color representation in CS courses, they do not seem to have the same effect on female students.

There are few, if any, female students in introductory CS courses. While the introductory courses are attracting greater percentages of students of color than the national average, the introductory courses are neglecting female students. Introductory courses have the potential to recruit another underrepresented group in CS—women. To do so, the PLC should focus on integrating initiatives to recruit more women into CS classes. Initiatives could include mentoring from a woman working in tech, networking with other women students in CS courses, internship or co-op opportunities at a tech company, and recognition or awards for successful women in CS classes. In catalyzing CS teacher collaboration, DPS can utilize introductory CS courses as a pathway toward engaging more female students in CS.

PLC Recommendation 2: Retaining students of color in CS courses

Although students of color are recruited into introductory CS courses, many students of color do not choose to take more advanced AP CS courses. CS teachers must utilize introductory CS courses to engage and interest students of color in CS and, thus, encouraging them to pursue AP CS courses. Since all teachers are developing their own curriculum, the PLC provides a community for teachers to develop an introductory CS curriculum that intentionally engages and interests all students, especially students of color, to continue into AP CS classes.

Additionally, the PLC should create recommendations for school administrators and counselors to retain students of color in CS beyond introductory level courses. Similar to recruiting women into introductory courses, initiatives outside of the classroom like mentoring, networking, internship opportunities, and awards or recognition may encourage students of color into AP CS courses.

PLC Recommendation 3: Fostering 21st Century Skills

All teachers emphasized that CS skills are important for all individuals, regardless of what industry and position they work in. One teacher, when explaining their passion for teaching CS, explained that "we are not looking for [students] to become computer scientists at MIT." Rather, teachers believe that although CS is not the forefront of the DPS agenda, "CS is the forefront of who we are." Teachers have emphasized that having some level of CS skills is important to participation in our society.

Additionally, CS teachers emphasized that, through project-based learning, they foster non-cognitive skills within their students. By collaborating on group projects, defining their own objectives, and iterating on their ideas, students strengthen non-cognitive skills like creativity, collaboration, resilience, and self-efficacy. All students can utilize CS courses as a platform to

develop non-cognitive skills that are highly valued for the workforce and for interpersonal well-being.

The PLC should focus on sharing activities, lesson plans, and project ideas that foster both CS skills and non-cognitive skills important to being a 21st century citizen through CS. More specifically, the PLC should focus on helping all students develop 1) CS skills to further their personal academic and career objectives, regardless of subject area, industry, or job role 2) non-cognitive skills through CS courses that are pivotal to personal and professional success in the 21st century. CS teachers understand and, probably, hope that not all students want to be computer scientists, data analysts, or software engineers. CS teachers, like all teachers, seek to foster students into responsible citizens and contributors to our society. By developing CS and non-cognitive skills through CS courses, students are empowered to reach their personal and professional potential in the 21st century.

LIMITATIONS

Since my interviews were all with teachers, I rely on their observations of students and personal experiences to guide my recommendation. Their observation of students' race or gender may not be completely accurate as students may identify with a different gender or race than their presentation may suggest. However, while teachers may incorrectly assume the gender or racial identity of some students, the overwhelmingly large percentage of male and students of color in classrooms suggest that CS classrooms in DPS tend to be mostly male and students of color.

I could not interview all DPS schools with CS classes. I reached out to all administrators within these schools but did not receive a response. Teachers interviewed did not explicitly state

that their experiences were representative of all CS teachers in DPS. However, the interviews yielded many issues on the state and district level. This suggests that many of the problems faced by teachers interviewed are shared by other DPS CS teachers.

Since my interviews focused on individual teacher experiences in the classroom, I did not draw out data about individual school culture and politics which can greatly influence CS instruction. Additional research should investigate the attitude and perception of school administrators' effect on CS education inequities. Also, research on student perceptions of CS in individual schools offer insight on the discourse and culture surrounding CS education in schools and their impact on which type of students opt into CS classes.

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