Scaling High School AP Computer Science: Access and Outcomes From Chicago Public Schools

John Wachen, The Learning Partnership, jwachen@lponline.net
Adam Shelton, The Learning Partnership, aqshelton@lponline.net
Steven McGee, The Learning Partnership, mcgee@lponline.net
Andrew Rasmussen, Chicago Public Schools, arasmussen@cps.edu
Erica Wheeler, Chicago Public Schools, ewheeler6@cps.edu
Lucia Dettori, DePaul University, ldettori@depaul.edu

Abstract: To understand student access and success in advanced coursework in computer science (CS), we investigated AP computer science participation and outcomes in Chicago Public Schools, where efforts are underway to broaden participation by scaling CS pathways to all schools across the district. We focus particular attention on the recently introduced AP Computer Science Principles course, which was created with the explicit goal to broaden participation among underrepresented students. We found that the district is making progress toward equitable access to AP CS courses and that inequalities persist in terms of effectively preparing underrepresented students for AP coursework.

Introduction

Efforts to scale computer science education (CS) across the U.S. have gained momentum in the past decade. Building on progress in states and cities, in 2016, President Obama announced the "Computer Science for All" initiative, which brought together organizations to scale CS nationally and ensure equal access to high-quality CS for all students (Smith, 2016). Similarly, in recent years there have been initiatives across the country to increase participation in Advanced Placement (AP) computer science, with a particular emphasis on traditionally underrepresented demographics. In 2012, the National Science Foundation partnered with the College Board to develop a second AP CS course with the purposeful goal of introducing CS to a broader range of high school students (the existing course, AP Computer Science A or CS-A, focuses on programming in Java and has historically served students already interested in programming as a career). The new exam, AP Computer Science Principles (CS-P), was first administered in the 2016-17 academic year and has grown substantially in subsequent years. By 2018-19, the national volume for CS-P exceeded CS-A by over 25,000 exams (College Board, 2019).

Across the nation, AP CS participation is growing dramatically, with the biggest gains among females and underrepresented student groups. Much of this growth has been attributed to the launch of CS-P, which resulted in a substantial increase in the number and percentage of AP CS exams taken by female, low-income, and underrepresented students (Code.org, 2019). However, even with these gains, participation remains unbalanced and performance gaps persist (College Board, 2018).

In 2016, Chicago Public Schools (CPS) established computer science as a high school graduation requirement as part of the district's Computer Science 4 All initiative, which aims to develop a computer science education "defined by equity, empowerment, and opportunity" (Office of Computer Science, n.d.). The graduation requirement is primarily fulfilled through the *Exploring Computer Science* (ECS) curriculum and professional development. Previous research on CS in Chicago has shown that participation in ECS represents equitable access to ECS as well as equitable course outcomes (McGee et al., 2018). As part of the ongoing work to scale up CS and develop K-12 CS pathways, the district is now focusing on expanding access to AP CS courses.

This expansion fits into the CPS strategic goal of growing the number of early college credits earned by high school students (through AP or dual credit courses). To encourage high schools to increase AP enrollments, the district includes an AP performance indicator as part of the School Quality Rating Policy (SQRP). Since 2011, the number of students taking AP courses has increased by 53%, despite gradual yearly declines in overall student enrollment in the district (Chicago Public Schools, 2018). However, similar to the national challenge, CPS also has substantial racial and gender gaps in AP participation (Emmanuel, 2019). This research seeks to understand the current state of access and effectiveness of AP CS in Chicago, which is a necessary first step to develop strategies to prepare and support students from underrepresented groups to succeed in computer science pathways.

Theoretical framing

In a recent review of scholarship on the AP program, Kolluri (2018) examined the program in terms of two dimensions: equitable access and course effectiveness. A focus on equitable access entails an examination of the availability of AP course offerings at schools serving primarily students of color and low-income students as well

as the distribution of AP participation by student subgroups within schools. Course effectiveness relates to the goal of AP courses to build college-level skills and help prepare students to succeed in college. Kolluri concluded that the AP program continues to struggle with the challenges of access and effectiveness. Additionally, among all AP subject areas, AP CS had particularly concerning racial inequities. The review offers three possible hypotheses to explain the continued struggle to achieve equitable access and effectiveness: 1) "Most underrepresented AP students cannot benefit from the program," 2) "AP curricula are being ineffectively taught to underrepresented students," and 3) "AP is a component of social reproduction."

We use the hypotheses from Kolluri (2018) as a theoretical framework for developing research questions that can be explored using data from AP CS in CPS. Given the recent introduction of the AP CS-P course and its emphasis on broadening participation, a particular focus of the analysis is student access and outcomes in that course. This paper describes the analysis and findings from the following research questions: To what extent is the district successfully broadening participation in AP CS? Are underrepresented AP CS students prepared for rigorous coursework and benefitting from the program? Is AP contributing to social reproduction?

Methods

To address our research questions, we analyzed student-level data for all students enrolled in AP CS courses in CPS. The first analytic step sought to identify patterns of access among underrepresented student groups and involved analyzing descriptive statistics using 2018-19 data on AP CS students in the district, along with national data on AP CS students. The second analytic step sought to examine the relationship between scores on the CS-P exam and student and teacher characteristics. We developed dimensions for each type of characteristic by grouping theoretically relevant measures and estimated a multilevel linear model to test the effect of student characteristics on AP exam score while controlling for teacher factors. For example, we hypothesized that math GPA, attendance rate, enrollment in a selective school, and grade level (when taking CS-P) all contribute to student preparation. The model used two years of data (2017-18 and 2018-19) to understand the relationship between student and teacher characteristics and CS-P scores.

Broadening access to AP CS

For the 2018-19 school year, the CPS dataset included 1277 AP students and 24 teachers from 18 different high schools in the district, including 7 selective enrollment schools (defined as providing "academically advanced high school students with a challenging and enriched college preparatory experience" (Chicago Public Schools, 2019)) and 11 non-selective schools. About 73% of the students in the dataset were from selective schools and the remaining 27% were from non-selective schools. The majority of AP CS students in the district (79%) were enrolled in the recently introduced CS-P course. Twelve of 18 schools offered only CS-P, two schools offered only CS-A, and four schools offered both CS-A and CS-P.

Overall, AP CS courses in Chicago are more equitable in terms of access for underrepresented students than AP CS courses nationally. Higher percentages of African American and Hispanic/Latino students participated in AP CS courses in CPS than AP courses nationally (see Table 1). Access to CS-P, in particular, was notably higher for underrepresented groups, suggesting that the district is progressing toward achieving its stated goal of broadening participation in CS through the implementation of CS-P.

Table 1: AP CS-P and CS-A Participation, 2019

	AP CS-A			AP CS-P		
Race/ethnicity	**National %**	**CPS %**	**Difference**	**National %**	**CPS %**	**Difference**
African American	3.9%	12.5%	8.6%	7.0%	15.0%	8.1%
Asian	33.1%	23.5%	-9.5%	21.5%	14.9%	-6.6%
Hispanic/Latino	12.0%	29.4%	17.4%	19.7%	39.5%	19.8%
White	43.4%	28.3%	-15.1%	44.6%	26.4%	-18.2%

However, comparisons to national averages may be less important than understanding the extent to which schools offering AP CS are representative of the district and whether AP participation within these schools is evenly distributed. Table 2 shows that the district schools offering AP CS are not representative of CPS high schools overall in terms of racial and ethnic composition. Schools offering AP CS have substantially lower percentages of African American students and higher percentages of Asian, Hispanic/Latino, and White students. Asian and White students, in particular, are highly overrepresented in AP schools compared to district averages. There is a similar pattern within AP CS schools. Specifically, there are lower percentages of African American and Hispanic/Latino students in CS courses compared to the overall student percentages in those schools.

Given the explicit focus of AP CS-P to increase participation rates for underrepresented students, we might expect to see more equitable access in CS-P within the district. Our findings indicate that CS-P is more equitable than CS-A with respect to gender and racial/ethnic composition. In 2019, 46% of CS-P exam takers were female, compared to just 26% of CS-A exam takers. Participation in CS-P is also less inequitable in terms of race and ethnicity, although both CS-A and CS-P do not yet reflect the demographics of the district or of the schools that offer AP CS. Also, neither CS-A nor CS-P reflect district or AP school percentages of students eligible for free or reduced lunch (CPS overall: 77%; AP CS schools: 65%; CS-A: 51%; CS-P: 54%).

Table 2: AP CS Student Demographics in CPS

Race/ethnicity	Overall CPS HS %	AP CS Schools %	CS-P Participation %	CS-A Participation %
African American	37.1	16.5	15.0	12.5
Asian	4.1	9.4	14.9	23.5
Hispanic/Latino	48.0	50.0	39.5	29.4
White	8.8	20.1	26.4	28.3

Broadening success: Student achievement on AP CS-P

Mean scores on the CS-P exam, math GPA, and percentage free/reduced lunch for CS-P students in Chicago are reported in Table 3. The overall mean score in CPS was just above 3, which is the score needed to receive college credit. However, on average, both African American and Hispanic/Latino students earned an AP score below this cutoff. These student groups also had lower average math GPAs and higher percentages were low-income than Asian and White students.

Table 3: AP CS-P Scores, Math GPA, and Free/Reduced Lunch by Race/Ethnicity in CPS

	Mean AP CS-P	Math GPA	FRL %
Overall	3.2	3.1	55.3
African American	2.4	2.7	64.3
Asian	3.7	3.5	59.3
Hispanic/Latino	2.8	2.9	77.3
White	3.7	3.4	16.9

To further investigate student achievement, we developed a multilevel linear model to estimate performance on the CS-P exam (n=1262). In Table 4, we present the results of the model, which estimates the effect of AP student demographics and student preparation measures, controlling for teacher preparation factors that we hypothesized would be associated with performance. Teacher preparation factors included the year they participated in district CS professional development, number of CS courses taught, and whether they have a background (degree or license) in CS.

Table 4: AP CS-P Performance in Chicago Public Schools, Adjusting for Teacher Preparation Factors

		Coeff.	SE
	(Intercept)	-0.561*	(0.711)
Demographics	Female	-0.189***	(0.045)
	FRL	-0.088	(0.054)
	Asian	-0.005	(0.127)
	African American	-0.252	(0.138)
	Hispanic/Latino	-0.188	(0.124)
	White	-0.085	(0.121)
Student Preparation	Math GPA	0.637***	(0.037)
	Attendance Rate	0.759*	(0.387)
	Grade Level	0.024	(0.037)
	Selective School	0.986**	(0.315)
Teacher Preparation	CS Courses Taught	0.021	(0.033)
	CS PD Year	0.156**	(0.054)
	CS Background	-1.048*	(0.386)

Significance: *** = p<0.001; ** = p<0.01; * = p<0.05

The results of the modeling indicate that several of the variables were statistically significantly associated with CS-P exam score. For demographics, female students scored lower, even after controlling for student and teacher preparation measures. The finding that low-income students did not score significantly lower on the CS-P (after controlling for student and teacher preparation factors) provides some evidence that the hypothesis that AP contributes to social reproduction may not apply to CS-P.

All of the student preparation measures except grade level were significant and positively associated with exam score, including math GPA. Given the differences in math GPA by student race/ethnicity (Table 3), this finding provides evidence in support of the hypothesis that underrepresented students may not benefit from the program because they have not been provided with the necessary preparation to succeed. That is, preparation appears to be critically important for maintaining effectiveness as the program expands to underrepresented students. Attending a selective school was positively associated with CS-P performance, which may reflect that students' middle school GPAs are one of the factors in the admissions system for selective high schools and math GPA is a significant predictor of AP performance.

Regarding the hypothesis that AP courses are ineffectively taught to underrepresented students, we do not have good measures of course implementation quality to investigate this claim. Teachers having a background in CS was significant but negatively associated with CS-P performance. This unexpected finding will be explored in the next phase of our analysis. Further quantitative and qualitative research into instructional quality and teacher preparation is needed to better understand the relationship between these factors and AP CS outcomes.

Overall, the results of our analysis indicate that the district has made progress on broadening access but that substantial access challenges remain both in terms of continuing to scale up AP offerings across district schools and ensuring equitable access within schools. Challenges also remain for broadening success through CS-P. The findings point to several areas for further investigation and may be particularly beneficial for informing the development of strategies to effectively scale up AP CS in the district. In the next steps of our analysis, we plan to further refine our models by developing a composite score for AP performance and estimating additional multilevel models. These findings about access to AP CS courses and the student and teacher factors that are associated with CS-P performance provide insights that may benefit the ongoing work in Chicago and in other districts around the country to create CS pathways for high school students and the important role that AP CS courses have in building those pathways. It is critical to understand AP outcomes, and, specifically, differential outcomes for underrepresented groups of students, in order to create equitable pathways in CS.

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