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BOARD # 348: CSforAll: Beyond Access, student outcomes of a co-instructional model for developing high school computer science teachers

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CSforAll: Beyond access, student outcomes of a co-instructional model for developing high school computer science teachers

Abstract

In recent years, significant private and public resources have been applied to increase access to computing education in K12 schools. While these efforts have led to growth in the number of high schools offering courses in computer science (CS), access and achievement for students historically underrepresented in STEM have lagged behind national averages. This paper examines the impact of the authors' work to address this issue as supported by a collaborative NSF CSforAll award. The work seeks to develop high school teachers' content knowledge and pedagogical skills in order to offer high-quality, equity-focused instruction of the Advanced Placement (AP) CS Principles curriculum. This was done through summer training and a unique capacity-building model where high school teachers co-teach with a university instructor for one full year. This paper presents a preliminary study of student attitudes from the 2022-2023 and 2023-2024 academic years as an indirect means for assessing the implemented approach to teacher development and the program overall. Across a diverse set of circumstances—different instructors, student grade level, student preparation, student race/ethnicity, etc.—we have observed some consistent trends. Participation in this AP-level CS course has led to a decrease in student self-efficacy as well as the students' own assessment of their interest in the field of CS. In contrast with these trends, the research team observed strong reporting of students planning to pursue CS-related careers following their high school graduation, with some notable exceptions.

Keywords

broadening participation, computer science education, high school

Introduction

To meet the technical workforce needs of domestic industries, significant resources have been invested by government, corporate, and non-profit organizations to increase student interest and skills in computer science (CS). Specifically, sizeable effort has been applied to develop high-quality CS curricula and train large numbers of teachers, primarily through one-week summer workshops. For example, the percentage of public high schools in the United States that offer a foundational computer science course has grown from 47% in 2019-2020 to 57.5% during the 2022-2023 academic year [1]. Despite these gains in access, there is still work to be done, especially for students historically underrepresented in the field. In 2021-2022, Black students made up only 6.73% of national Advanced Placement (AP) CS exam takers [2] even though they make up approximately 15% of the overall high school population [3]. Furthermore, only 32.37% of Black AP CS exam takers passed, compared to the overall pass rate of 64.62% [2].

With the support of an NSF CSforAll award, the authors have implemented a program to develop high school teachers in southeast Michigan to offer high-quality, equity-focused instruction of the AP Computer Science Principles (CSP) curriculum through summer training and co-

instruction with a university faculty member. These activities seek to develop the teachers' pedagogical content knowledge, including through the development and implementation of culturally-responsive CS lessons [4]. Prior work by the authors has examined the high school teachers' perspectives on this co-instructional model of development [5]. In this paper, the focus is on student attitudes and outcomes from the associated AP CSP classrooms during the 2022-2023 and 2023-2024 academic years, including years when the university co-instructor was present as well as years when the high school teachers were leading their classes independently. Changes in student self-efficacy, interest in CS, and post high school graduation plans as determined by surveys given at the beginning and end of a course are examined.

Background and program description

During the two academic years examined, data from 271 students was collected. These students were enrolled in an AP CSP course at one of eight different high schools, each with their own classroom teacher. All of the high schools are urban, located in the greater Detroit region, and serve predominantly low-income students, though there is significant variation in the specific contexts of each school. **Table 1** provides some characteristics of the schools where the courses were offered (data from [6]). Across the students enrolled in the AP CSP courses, 35% identify as Hispanic/Latino, 34% as Black, 12% as Asian/Pacific Islander, 10% as Arab American/ Middle Eastern, 8% as White, and 2% preferred not to answer. A significant number of students came from families whose parents immigrated to the US, for example, approximately 40% of students were from homes where English was not the primary spoken language. In terms of gender distribution, 39% of the students identified as female, 56% as male, and 4% as non-binary or preferred not to say. Most of the students enrolled in the course were seniors (46%) or juniors (27%), but some classes had a significant number of sophomores (16%) and freshmen (11%).

Table 1 Characteristics of high schools in the study

School	Racial/Ethnic Makeup	Free/Reduced Cost Lunch	College Ready*	Grads Enroll in 4-yr College**
A	> 99% Black	87%	6%	39%
B	> 99% Black	73%	< 5%	15%
C	50% White, 34% Asian, 15% Black	88%	10%	47%
D	57% White, 22% Black, 15% Latino	82%	13%	26%
E	98% Black	85%	< 5%	18%
F	94% Latino, 3% Black, 2% white	99%	12%	34%
G	62% White, 27% Latino, 8% Black	85%	13%	26%
H	Data not publicly available			

* SAT exceeds 530 math, 480 verbal, ** percentage of grads who enroll within 6 months

Across the two years of the project, the university co-instructor was present for seven of the total of 12 sections of AP CSP offered. Two of the eight teachers were trained via the co-teaching model prior to the beginning of the current CSforAll award as part of a larger effort that developed teachers of two other engineering courses, in addition to AP CSP. Goals of program include building awareness and interest in tech fields through field trips, guest speakers, and connecting students to related extracurricular opportunities, in addition to the technical skills

taught within the courses [7]. This overall approach has continued with the new standalone AP CSP courses introduced through the efforts of the current project. Eleven of the 12 class sections used curriculum from Code.org; one section primarily employed materials from CompuScholar while including supplemental lessons from Code.org. For the courses launched under the current award, the Code.org curriculum was adapted to make it more culturally responsive.

Student outcomes

For the classes under study, the research team was able to collect both pre- and post-course survey data from 173 students. In spite of differences across the backgrounds of the students (gender, race/ethnicity, age, experience with CS, etc.) and the contexts in which the courses were taught (instructor, school, etc.) the team observed some common trends in terms of student self-efficacy, interest in CS fields, and plans post high school graduation.

i. Student self-efficacy

Students were asked to respond to a number of statements related to their ability to be successful, generally, and in STEM fields, specifically. The pre- and post- surveys employed a Likert scale with the responses: strongly disagree, disagree, neutral, agree, and strongly agree, corresponding to numerical values from 1 (strongly disagree) to 5 (strongly agree). Across different environments and student backgrounds, it was observed that student responses primarily indicated a decrease in confidence. For example, in response to the statement, "I would do well if I was to get a job in a STEM-related profession," the average student response decreased from 3.55 at the beginning of the course to 3.34 at the end of the course. In response to the related STEM-focused statement, "I am academically prepared to complete STEM coursework at a college or university," the average response at the start of the course was 3.65 compared to 3.46 at the end. Even when the STEM qualifier is removed from the statement, student responses still did not show an increase in self-efficacy. Student responses to the statement "I feel confident in my ability to complete college-level work" nominally decreased from an average of 3.74 on the course pre-survey to 3.70 on the course post-survey. These types of trends have also been observed in the other engineering courses in the STEM pathways program [7].

Some thoughts on why the students' confidence did not increase is that the AP CSP course may have been more challenging than the students expected. Such an AP course is meant to be consistent with college-level work and AP CSP, in particular, requires abstract thinking, the solution of open-ended problems, and a high level of reading comprehension involving significant new vocabulary. Students expecting strictly a "coding" class may have been surprised by the more academic aspects of the course as well as its pace. In some other applied STEM courses, it is possible for students to "hack around" to make something work without needing a deeper understanding of their solution that they then are required to communicate to others. Entering the course, it is also possible students may have overestimated their prior knowledge.

ii. Interest in CS fields

Comparison of the pre- and post-course surveys also indicated a decrease in the students' interest in CS-related fields. In response to the statement "I am interested in learning more about CS,"

students' interest decreased from an average of 3.86 at the beginning of the course to 3.34 at the end. The fact that the course provides a significant introduction to CS could partially explain the decrease. For the statement, "I am interested in a CS-related job in the future," the students' average response decreased from 3.25 to 3.11 over the course of the year. These trends are observed fairly consistently across different student subgroups.

In contrast to the students' responses to the questions about interest, the surveys told a different story when students were asked about their post high school graduation plans. Students were asked, "What do you plan to do after graduation?" at the conclusion of the course. In response, the students could indicate whether they plan to attend a 4-year university or a 2-year college or certification program, they plan to enter the workforce directly, or are unsure. The students could then further specify what they plan to major in or what kind of job they plan to pursue. Additionally, the research team collected actual student destination data from the National Student Clearinghouse. Adding the data from the post-course survey for students for which we didn't have clearinghouse data, including students that hadn't yet graduated high school, we had planned and actual destination data for 204 students. For this group, 29.9% of the students chose to, or plan to, pursue a degree from a 4-year or 2-year college in a CS-related program, including fields such as computer science, engineering, cybersecurity, computer information systems, etc. This level of interest is much stronger than national averages, especially considering the college-going rate of the students at the high schools in the study (see **Table 1**).

One thought about the difference expressed by this data is that even though a student's self-expressed interest in CS decreased, when they were faced with a concrete question about their future and they considered the real-life implications of their choice, they may be more likely to choose a CS-related field because it provides the opportunity for secure, well-paying employment. An indication of this is that when we consider only the students' responses on the post-course survey, and don't consider clearinghouse data, only 25% of the respondents indicated a plan to pursue a CS-related degree. Another indication of this is that 37.3% of upper-class students (juniors and seniors) chose or plan to pursue a CS-related field, while only 11.1% of under-class students (freshmen and sophomores) plan to. This indicates that as more students graduate, the percent pursuing CS-related careers could actually increase. Another possibility for the difference is that some of the fields the research team classified as being CS-related, such as engineering or cybersecurity, may not be thought of as such by the students.

Looking more closely at the destination data, other interesting trends emerge. Male students chose/plan to pursue CS-related fields at an overwhelmingly higher rate than female students, 42.9% vs. 10.8%. Also, students that chose to be in the course were much more likely to pursue a CS-related career than those students that were placed in the course without actively choosing it. Of the students that chose the course, 40.2% had a CS-related destination as compared to only 14.3% of the students that didn't choose the course. While this may be unsurprising, if we dig a little deeper and look at the students that didn't choose the course and were not okay with it, the percentage of students who chose a CS-related destination drops to 0%. In the best case this means we could be wasting the time of students placed in the course who don't want to be there, but in the worst case, we could actually be turning students against CS.

Conclusions and future work

The preliminary results of this study indicate that while the AP CSP classes initiated by the project did not seem to increase student self-efficacy and self-indicated interest in the field of CS, the courses produced students that chose or plan to pursue a CS-related career at an impressive rate of 29.9%, with some notable exceptions. One exception was women students who were identified to be four times less likely than their male counterparts to pursue a CS-related career. One possible implication is that in communities such as those in the study that lack role models in tech fields generally, women may be especially vulnerable. Furthermore, it seems to indicate the importance of exposing women to CS fields well before they reach high school. Another result of the study showed that students who selected to be in the course plan to pursue a CS-related career at a much higher rate than those students that did not. This result also demonstrates the importance of cultivating student interest prior to enrolling them in AP CSP, i.e. at a younger age. This also indicates the importance of engaging school counselors and administrators in the process to build pathways into AP CSP and to develop structures for helping to market the course and to identify students that are interested in CS.

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