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Generating Interest in Foundational Computer Science in High Schools: A Northwest Florida Case Study

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Abstract: Computer Science drives innovation and discovery, and Computer Science classes in High Schools, particularly AP Computer Science Principles, have also been linked to better performance in other High School courses, but a Code.org report shows that the state of Florida, particularly the Northwest Florida region, is far behind the rest of the nation in offering Computer Science classes at the High School level. This paper discusses strategies that are can be implemented to improve High School Computer Science offerings in like-regions that have lower Computer Science offerings. The paper also discusses the challenges that come up in addressing this issue and presents potential avenues for addressing these challenges. One major challenge that is addressed is creating the culture of inclusive computing by getting more women and under-represented groups interested in taking Computer Science courses. Though this is a Northwest Florida case study, most of the strategies discussed in this paper would be applicable to any other part of the country with low Computer Science offerings with a similar socio-economic background.

Keywords: Computer science education, Foundational computer science, AP computer science principles, High schools, Underrepresented groups

Introduction

In addition to Computer Science driving innovation and discovery, several studies have shown that students taking Computer Science classes in high schools also perform better in other high school courses (Brown & Brown, 2020; Code.org., 2015; Code.org., 2021; Warne, 2017). Computer science courses deepen critical thinking skills, empowering students to grasp abstract or complex ideas (Csizmadia, et al., 2015. Molnar (1997) states that cognitive computing means that every person is an organic computer, with an inexhaustible potential to develop "higher-order, thinking and problem-solving skills." However, only slightly more than half the high

schools around the country now offer Computer Science, and inequalities exist (Klein, 2021). Code.org (2022) reports that the percentage of high schools offering computer science courses jumped from 35% in 2018 to 51% in 2021, but rural and urban schools, and schools that serve the lower socio-economic strata, are less likely to offer foundational computer science (Roberts, et al., 2022; Klien, 2021).

The demand for Computer Science (CS) tech skills is ever increasing. A 2022 Tech Work Report found that an increasing rarity of skilled technology workers is forcing companies to make difficult decisions. 80% of the Executives surveyed said that they would hire people for tech positions even if they were non-college-degree holders (Jones, 2022). Hence, since the US produces too few people with CS Tech skills, introducing CS during compulsory schooling years can be a key to maintaining economic growth, increasing employment opportunities and reducing the historical gaps in gender and race (Hansen & Zerbino, 2022).

But, there are several challenges to introducing and adequately offering Computer Science in High Schools, even at the national level. One of the major challenges is the shortage of teachers to teach Computer Science. This problem has of course been compounded by the Covid-19 pandemic, which has brought about a general nation-wide shortage of teachers (McMurdock, 2022; Harris, 2022; Walker, 2021). In terms of adequately offering Computer Science in high schools, the United States will need more than 30,000 high school teachers qualified to teach CS by 2025 (Thompson, 2018). Code.org (Nunn, 2018) reports that 87,000 K-12 teachers, mostly elementary school teachers, have attended Code.org workshops in an attempt to teach CS, but only a small percentage of these are high school teachers.

In addition to national challenges, the Escambia County School District (ECSD) in Northwest Florida, faces additional challenges, which is the focus of this paper. This paper discusses strategies that are were implemented to improve high school foundational Computer Science offerings, by introducing AP Computer Science Principles (CSP) as a foundational computing course, in the Escambia County School District in the panhandle of Florida. This is a case study of Northwest Florida, but most of the strategies discussed in this paper will be applicable to other parts of the country with similar demographics and low Computer Science offerings.

The rest of this paper is organized as follows. Section 2 presents the provides a background of the demographics and socio-economic state of ECSD; section 3 presents the challenges we faced, and section 4 presents steps that we took to address the challenges; section 5 presents the outcomes of our efforts after one year of work with ECSD, and section 6 presents the conclusions; and finally, section 7 presents the future works.

Background

In order to understand the issues that we faced in ECSD, in this section we present some demographics of ECSD in Pensacola, Florida. The ECSD is a public-school district comprised of 40,386 students in grades Pre-K through K-12. The district hosts 43 elementary schools, nine middle schools, seven high schools and 16 alternative schools. Records from Florida Department of Education (FLDOE) report the following student academic proficiency levels in ECSD: (a) 48% proficiency in reading, as compared to 57% proficiency for the

State of Florida; and (b) 47% proficiency in mathematics, as compared to 60% proficiency for the State of Florida. 41.20% of the teachers in ECSD have less than 4 years of teaching experience, as compared to 26.9% for the State of Florida. FLDOE classifies 72.10% of the ECSD students as economically disadvantaged, a number much higher than the Florida State average of 61.40%. The district's average per pupil expenditure is $10,050, as compared with the national average for per pupil expenditure of $12,239. The student-teacher ratio for the district is 15:1, as compared to the national student-teacher ratio of 16:1. The school district is ranked #17 (for most diverse School District) out of 67 districts in Florida. In terms of student demographic information, 48.3% of the students are male and 51.7% are female. In terms of ethnicity, Whites make up 47.7%, Blacks make up 34.9%, Hispanics/Latinos make up 6.8%, Asians make up 2.5%, American Indian/Alaskan make up 0.8% and other races make up the rest, 7.2%. This information makes the following points: (i) ECSD is a highly diverse school district; (ii) ECSD falls in one of the lowest socio-economic strata in the State of Florida; (iii) ECSD has a lower proficiency than the State of Florida in terms of reading and Math; and (iv) there are fewer qualified teachers in ECSD, as compared to the state of Florida.

The following section presents a break-down of the number of students who took AP Computer Science Principles (CSP) before our program was implemented and their pass rates. Table 1 presents the number of students in ECSD who took the AP CSP exam in the years, 2017-2020, and the respective pass rates (these numbers represent the totals of all seven high schools in ECSD). The passing score is taken as an AP CSP score of 3 or above. The last line of Table 1 shows the number of students who took the AP CSP exam in the State of Florida in 2020. Table 2 presents the number of students who took the AP CSP exam, by gender, and the respective pass rates, for the years, 2017-2020. Table 3 presents the number of students who took the AP CSP exam, by race, and the respective pass rates for the years, 2017-2020. The last line of Table 3 presents the corresponding numbers for the State of Florida.

From Table 1, it can be observed that the pass rates in ECSD are lower than the State of Florida average pass rates. Although the pass rate was higher in ECSD in 2017, they dropped after that. There was also a drop in the number of students taking the exam in ECSD from 2019-2020, though it would be difficult to say if this is due to Covid-19, though nationally the number of students that took the AP CSP exam doubled from the preceding year (Bruno, Pérez, & Lewis, 2022).

Table 1. Number of Students who took AP CSP Exams and Pass Rates

AP CSP	Took Exam	% Passed
ECSD 2017	28	89.29%
ECSD 2018	55	47.27%
ECSD 2019	61	54.10%
ESCD 2020	39	58.97%
State of FL 2020	11443	66.50%

From Table 2, it can be seen that the ratio of females to males in AP CSP is almost 1:3 in ECSD versus almost 1:2 in the State of Florida. The pass rates, however, are higher for females, both in ECSD and in the State of Florida. Figure 1 presents this graphically.

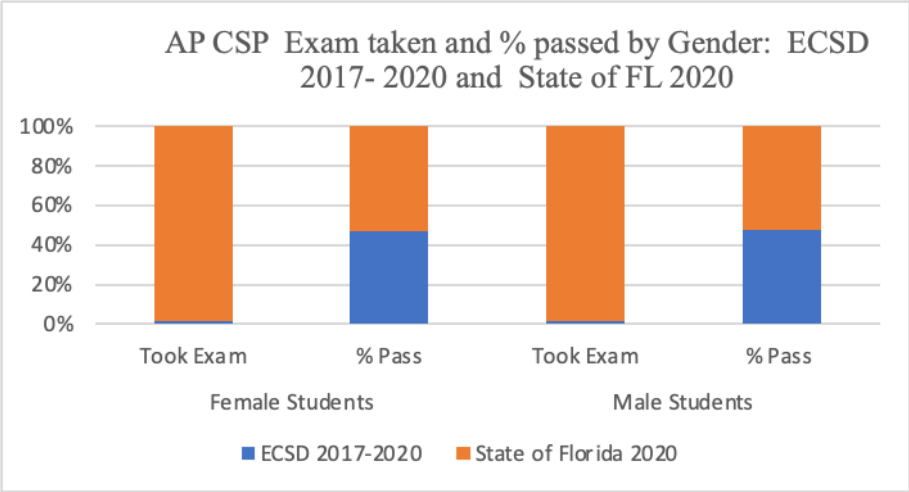

Figure 1. AP CSP Exam Taken and % passed by Gender in ECSD and FL

Table 3 and Figure 2 shows that the number of Black, Hispanic, and multi-racial students taking the exams are lower than the number of White students and their pass rates are also lower than the White students (though the pass rates for Asians is higher). The pass rates of all categories are also lower that the State of Florida average pass rates for all groups except for Asian students. This demonstrates the need to focus on all groups, especially URGs such as Black and Hispanic students.

Table 3. Number of Students who Took AP CSP Exams and Pass Rates by Race

AP CSP	Asians		Blacks		Hispanics		Multi-racials		Whites	
	Took Exam	%Pass	Took Exam	%Pass	Took Exam	%Pass	Took Exam	%Pass	Took Exam	%Pass
ECSD 2017-2020	33	87.80%	23	39.10%	18	50.00%	16	31.30%	92	58.70%
State of FL 2020	1310	78.70%	1011	46.30%	3687	64.80%	482	63.80%	4603	69.60%

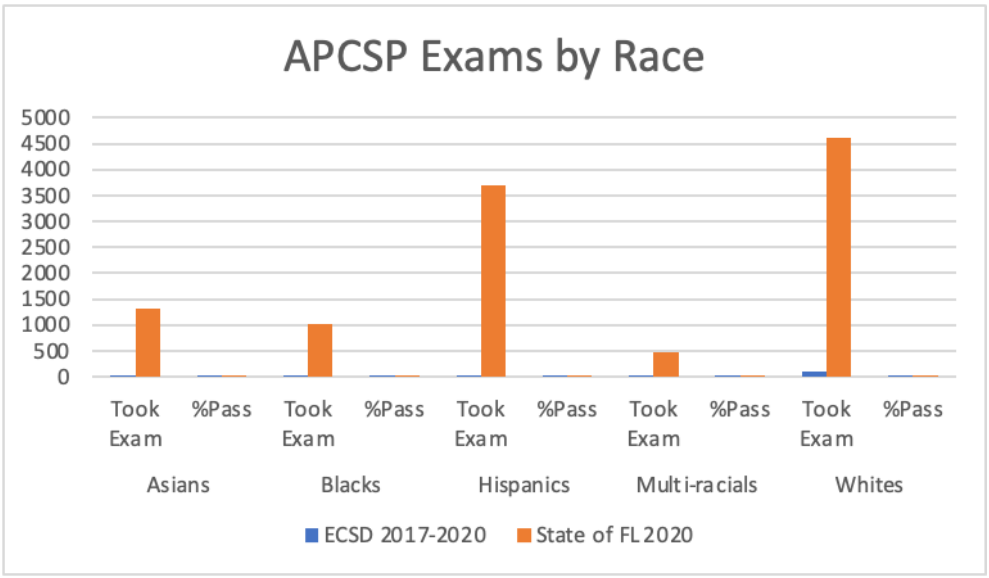

Figure 2. Number of Student who Took AP CSP Exams and Pass Rates by Race

The above background provides an understanding of the situation we are trying to address, which leads into the challenges we face, which are presented next.

Challenges

Given that ECSD is a highly diverse school district that falls in one of the lowest socio-economic classifications in the State of Florida and has a lower proficiency than the rest of the State of Florida in terms of reading and Math, compounded by the fact that there are few qualified teachers to teach Computer Science, there were several challenges we faced:

(i) Shortage of teachers qualified to teach foundational computer science. The nation-wide crisis (Bruno, Pérez, & Lewis, 2022) is also being reflected in ECSD.

(i) Culture of Computer Science is not existent.

(ii) Low representation of women and under-represented groups. This nation-wide issue (Robert et al, 2022) is also being reflected in ECSD.

(iii) Technical issues:

a. Do the high schoolers have the right Math background?

b. Will AP CSP count as credit towards high school graduation?

c. AP CSP does not count as credit by the Florida's SUS institutions

d. AP CSP is not a required course for Florida's Bright Futures Scholarship

Addressing the Challenges

To address the above challenges, the following steps were taken:

(i). Creating the culture of Computer Science

(ii) Being inclusive of women and under-represented groups

(ii). Recruiting and training teachers

(iii). Educating counselors

(iv). Developing a relationship with all the parties (administrators) involved in the decision-making process.

(v). Addressing the technical issues by making Computer Science regular part of the curriculum.

Creating the Culture of Computer Science

One major challenge that had to be addressed in ECSD was creating the "culture" of Computer Science. There was no "culture" of Computer Science in the area high schools, and there were several reasons for this, listed below. Unless one understands the reasons for not having the culture of Computer Science, it is not possible to adequately address the issues. The reasons for not having the "culture" of Computer Science in area high schools are:

(i). Since there were almost no qualified teachers to teach AP Computer Science Principles, the pass-rates were not very high, hence students did not want to take a course where did would not do well. Case in point: In Pensacola High School, one of the premier public high schools offering an International

Baccalaureate program, in Pensacola, Florida, where there was only a facilitator in class, monitoring students preparing for AP CSP, as students tried to learn on their own from Code.org. Students need a teacher in front of the class, not a passive facilitator. Situations like these discouraged students from taking AP CSP. So, the first challenge in creating the culture was bringing back the confidence of the students.

(ii). Since ECSD falls within the lower socio-economic strata, and most of the parents are not aware of the benefits of taking Computer Science, the high schoolers are not encouraged to take computer science;

(iii). AP CSP does not count as a course fulfilling the Bright Futures and other scholarship requirements in the State of Florida; Students in the lower socio-economic strata are highly dependent on a scholarship if they are to pursue higher studies, hence this is a limiting factor for students.

(iv). Many students did not know that it could count as a High School graduation requirement in place of a Math course (as a Math elective);

(v). Many students did not have or feel that they did not have the adequate Math skills.

Therefore, to introduce and cultivate the culture of Computer Science, we needed the participation of a lot of parties: teachers, high school guidance counselors, as well as the school administrators. Parents play a role in this too. In the following sections we discuss how each of these parties played their unique roles in cultivating the "culture" of Computer Science.

Being Inclusive of Women and Underrepresented Groups

For women and Under Represented Groups (URGs), general messages about high salaries and excellent job placement rates are important, but may not be sufficient to encourage them to take Computer Science. Traditional agents of socialization, such as family members (especially parents), are still very strong with contemporary prospective students (Arendt & Dohrman, 2016). URGs face barriers to inclusion like family pressure to begin work immediately after high school, or to stay near one's hometown, in addition to lack of knowledge about possible computing careers. URGs needed to be educated about career opportunities in the tech fields around the area.

Arendt & Dohman (2016) also found that women responded better to messaging where computing is treated as a profession that helps people, where they can work with people. Self-expression is also very appealing to women. This means that, instead of giving examples of hacking computers, examples should be given on how robots (computers) could be used to do routine tasks around the house, or the current efforts made in wearable technology that intersects with the fashion industry.

Hence the messaging and examples given to women and URGs have to be different and these points were in working sessions with the teachers and multiple working sessions with high school guidance counselors, so that they could be more aware of and be inclusive of the different groups, as they thought of recruiting students for AP CSP.

The National Council for Women in Technology (NCWIT (Bradberry, 2021) was also introduced to the high

school guidance counselors as well as teachers in an effort to be inclusive of women and underrepresented groups.

Recruiting and Training Teachers

Recruiting Teachers

Most current computer science teachers have not received pre-service training in computational methods, and this is an issue that most of the nation also faces (Nager & Atkinson, 2016). Hence, teachers are unfamiliar with Computer Science content knowledge as well as pedagogical practices in Computer Science. Also, Computer Science teachers are still new to the field of education. In fact, nationwide, less than 20% of the Computer Science teachers have more than 10 years of experience (Code.org 2021). Hence, most states still do not require individuals teaching computer science courses to hold a certification in computer science (Code.org 2021; Amiel & Blitz 2022). With respect to recruiting teachers, ECSD faces some of the same challenges that are being faced nationwide. Hence, for our program, it was not possible to recruit teachers with pre-service training in computational methods. Most of the teachers recruited were Math or Business Education teachers.

Training Teachers

In terms of training the teachers, there is established evidence that a week of training is not sufficient preparation to teach a new subject. Teachers need significant experience working in their particular discipline (Christensen Institute, 2019). Research shows that these types of trainings are typically done in passive modes, disconnected with realities of the classroom, and with limited follow-up (Ascione, 2022, Herrmann. et al, 2016). Cornett and Knight (2009) found that teachers successfully implement new teaching strategies learned in workshops only about 15% of the time, but if this is followed by instructional coaching, successful implementation reaches 85% (Martin. et al., 2011).

Therefore, although there are Computer Science content providers like Code.org available to provide content knowledge of Computer Science, this is not sufficient, since teachers will still have the fear of “programming” and teaching programming. Loucks-Horsely, et al. (2003) also found that professional development should be of sufficient duration (Cobb, et al., 2013), hence teachers need a form of continuous support mechanism to teach a whole year of Computer Science. Through our program, teachers were taught appropriate pedagogies for delivering the Computer Science, particularly with respect to algorithms, programming and development of computational thinking skills (Coburn & Penuel, 2016).

Our project utilized an instructional coaching model, adapted from Arendt & Dohrman (2016), that employed a constructivist pedagogical approach, to be the continuous support mechanism for high school Computer Science teachers in ECSD, after the teachers had been trained through Code.org. Instructional coaching interventions have shown to be significant predictors of student achievement (Bryk, et al., 2017). Teachers in ECSD were trained, taught instructional material, for a whole year.

Pedagogical guidance to help teachers teach algorithmic and programming concepts

The main question to address here is, what good techniques/strategies help students understand algorithms and programming. As mentioned by Sentance and Csizmadia (2016), teachers were encouraged to use the following strategies:

- Unplugged activities
    - Teachers were encouraged to use unplugged activities, for example, using drinking mugs to illustrate memory locations or variables in programming.
- Collaborative working
    - Teachers were encouraged to include team work, peer mentoring, paired programming, and collaboration in their classrooms. Another example could be where the teacher uses class time to break down sample problems together as a class, and then coding in teams.
- Computational Thinking
    - This includes logic or algorithmic thinking, decomposition, problem solving and abstraction. An example of this would be, repeatedly breaking down a program into the smallest possible pieces, and then building it back up.
- Contextualism of learning
    - Here teachers would be taught to talk about relating computing concepts to real-life, for example, making a cup of coffee.
- Scaffolding programming tasks
    - This would be strategies that teachers would help their students with understanding program code. A good example would be to use traditional methods to think through the code first. So, giving a piece of code on a paper, which students would to type in, and in the process, think about what they are typing in and fix the errors that occur when compiling the program. Then the teacher would have a discussion of what the students just typed in, with the help of showing trace tables.

Counselor Development

Since ECSD falls within one of the lowest socio-economic indexes in the state of Florida, and to also deal with the other challenges ECSD faces, for example, addressing the issue of increasing women and URG enrollment in high school AP CSP courses, high school guidance counselors were identified and trained. A lot of emphasis was placed on counselor training.

Counselors were educated about the field of Computer Science. The main message was that computing is applicable to any field, and all students don't have to become Computer Science majors. Counselors were taught that AP CSP basically introduces computational thinking, which is a way of thinking. Counselors were also informed that a Computer Science course could be substituted for a Math course in the State of Florida, or be taken as an elective.

Counselors were educated about computing careers. They were also taught what would be helpful in recruiting females and URGs into AP CSP courses. Several other facts were laid out to them, for example, in 2019, the demand for Computer Science graduates outpaces supply, the median annual wage for students with computing and technology occupations.

High school guidance counselors were also trained by availing of the training and resources provided by National Center for Women and Information Technology (NCWIT) Counselors for Computing (C4C) materials (Bradberry, 2021). NCWIT resources are geared towards educating K-12 counselors, specifically for recruiting in Computing fields. Guidance counselors attended NCWIT's webinars and meetings. C4C provides school counselors with the information and resources they need to advise students about careers in computing and technology and paths in those careers. Counselors were presented with: (i) A C4C Information Sheet that which presented the big picture about technical education and careers; (ii) Counselor Talking Points, that is, they were presented with the key points needed to convey to colleagues, administrators, students, and parents about computing education and careers.

In addition, workshops were held for the high school counselors, in which works like "*Unlocking the Clubhouse: Women in Computing*," by Margolis and Fisher (2003) and "*Stuck in the Shallow End: Education, Race, and Computing*," by Margolis, et al., (2010) were discussed. These are two notable works on URGs. Other topics that were discussed with counselors were career choices for the students, once they have a computing background. Several sessions were held with the high school guidance counselors throughout the year to address several of the challenges, and hence the guidance counselors were also able to address several of the challenges we faced. High school guidance counselors played a major role in increasing enrollment as well as increasing diversity in AP CSP.

Developing a relationship with all the parties involved

In order to successfully offer a foundational computing course, it was also necessary to have the support of school officials, for example, the School Principles and Assistant Principles. There had to be a buy in from these groups, hence a relationship was built with school officials.

Making Computer Science Part of the Curriculum

Foundational Computer Science was going to be introduced to the ECSD high schools through AP CSP. So, the first question is, why was AP CSP chosen?

Introducing AP CSP: Why AP CSP?

The idea that computer science is synonymous with programming remains a common misconception in computer science education (Amiel & Blitz, 2022). AP CSP is an introductory computing course that stresses analytical and critical thinking and brings students into the field of Computer Science using hands-on, project-

based, collaborative learning (Newsroom, 2022). Mainly because it stresses on computational thinking, it is widely popular as a foundational Computer Science course in high schools (Warne, 2017).

Newsroom (2018) states: (i) students who take AP CSP in high school are more than 3 times as likely to major in Computer Science in College; (ii) AP CSP can become a path to more STEM coursework; (iii) AP CSP is helping in increasing diversity – gaps in enrollment by race/ethnicity are greatly reduced.

Addressing the Other Technical Challenges

The other technical challenges were addressed as follows:

a. Do the high schoolers have the right Math background? Messaging was done with the help of the school guidance counselors as well as the teachers that were going to teach AP CSP, that the only pre-requisite for this course was Algebra 1.

b. Will AP CSP count as credit towards high school graduation? Messaging was done with the help of the school guidance counselors that this course could be used as a Math elective.

c. AP CSP does not count as credit by the Florida's SUS institutions. Credit for AP CSP is given at the 1000 level.

d. AP CSP is not a required course for Florida's Bright Futures Scholarship. Unfortunately, there is no direct policy in place yet to take care of this. But, the idea that AP CSP helps students to do well in other courses was reinforced.

Results: Outcome of These Efforts

After a whole year of educating teachers and counselors, introducing the "culture" of computer science, as well as adding AP CSP to the curriculum, we were able to report significant improvements in the numbers of students taking AP CSP in ECSD in 2022-2023. As Figure 3 shows, there were only 26 students registered for AP CSP in ECSD in 2021-22, and this number increased to 201 in in 2022-2023, a seven-fold increase. This itself is a major success. Of these, as Figure 4 will show, 67% are males and 33% females. This is also an increase in the number of females taking AP CSP. Figures 5-8 also shows an increase in other ethnic backgrounds. Figures 8 and 9 show a breakdown by school for both race and gender respectively.

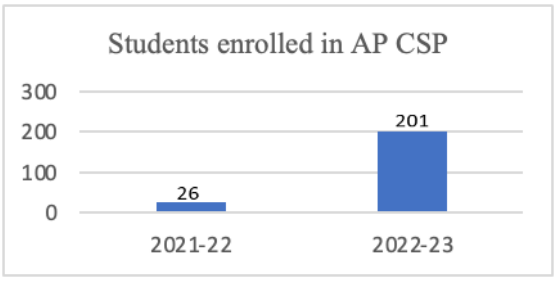

Figure 3. Increase in Students Enrolled in AP CSP

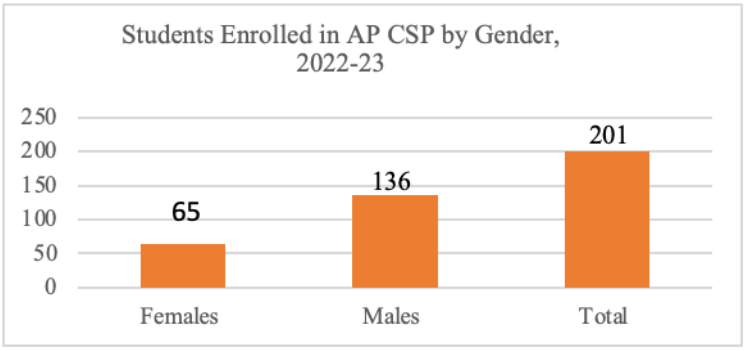

Figure 4. Students Enrolled in AP CSP by Gender, 2022-23

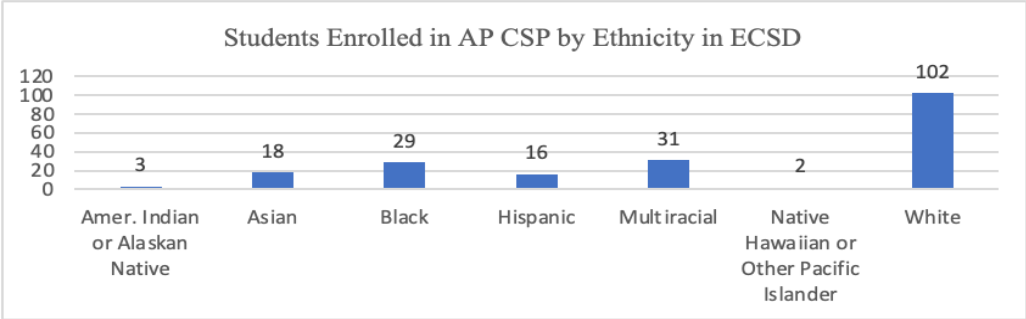

Figure 5. Students Enrolled in AP CSP by Ethnicity in ECSD, 2022-23

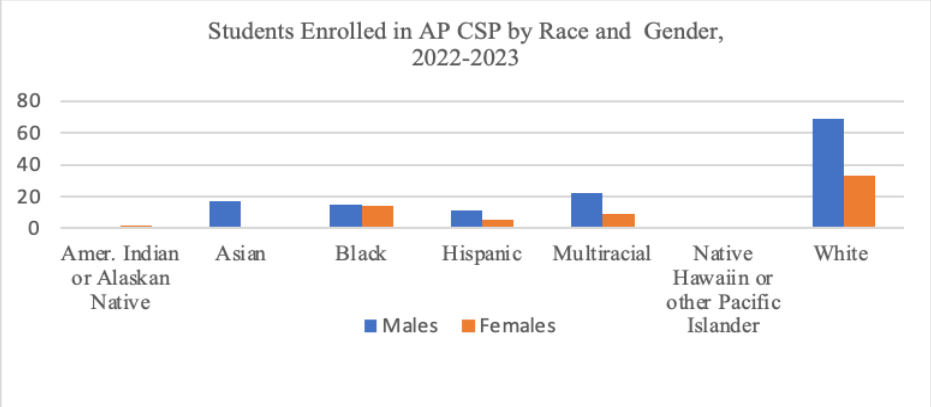

Figure 6. Students Enrolled in AP CSP by Race and Gender in ECSD, 2022-23

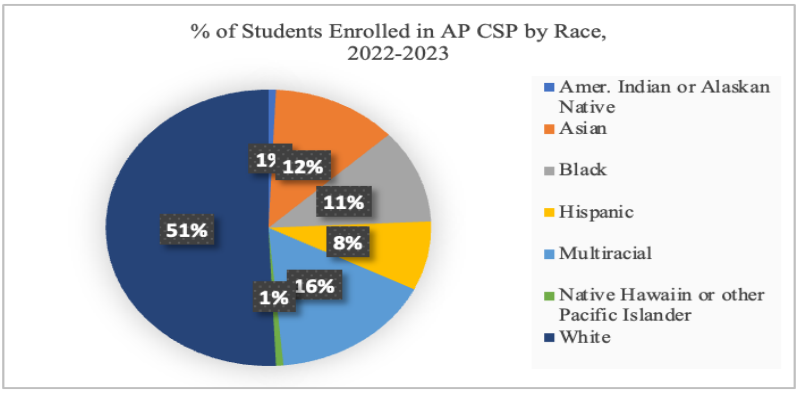

Figure 7. % of Students Enrolled in AP CSP by Race in ECSD, 2022-23

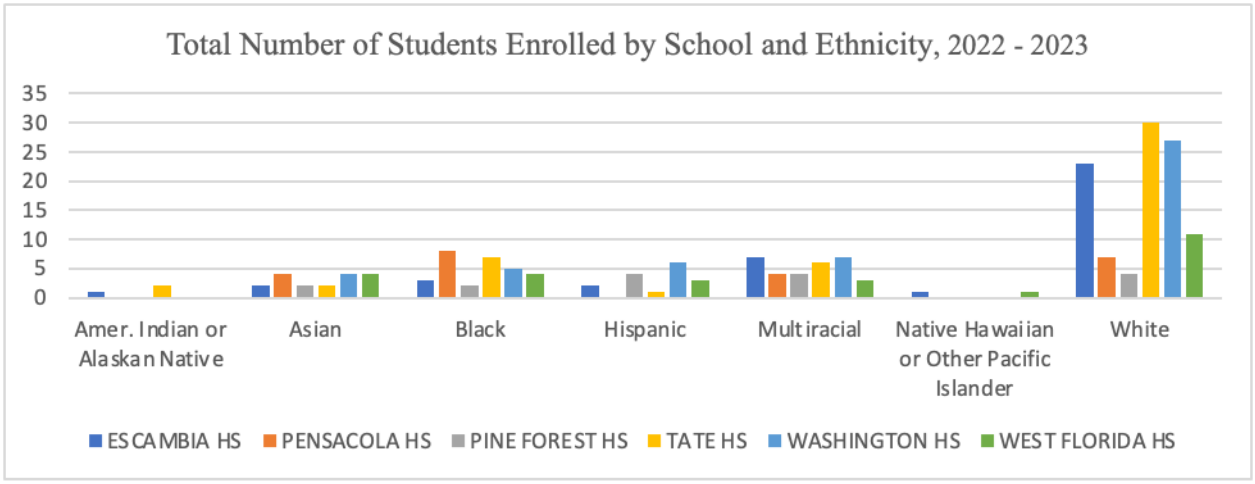

Figure 8. Total Number of Students Enrolled by School and Ethnicity in ECSD, 2022-23

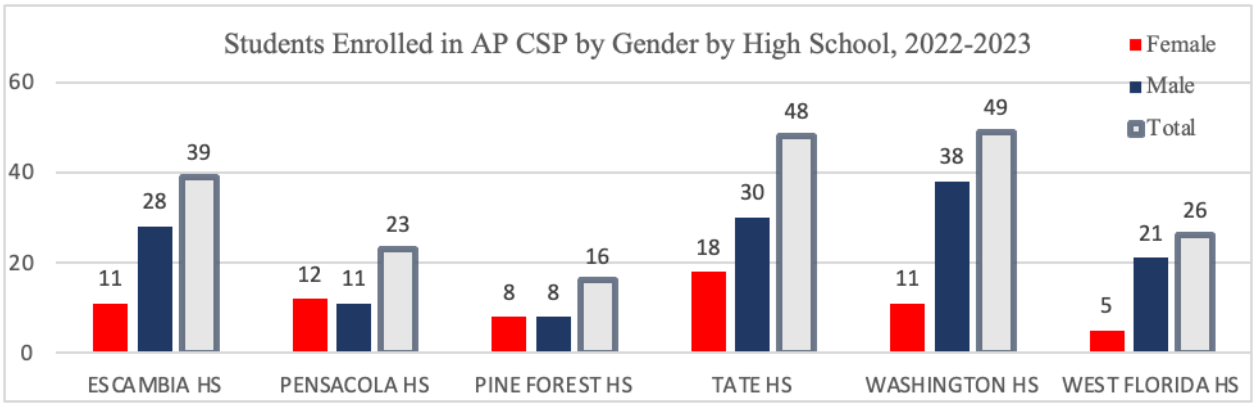

Figure 9. Students Enrolled in AP CSP by Gender by High School in ECSD, 2022-23

In addition, we also have a very good relationship built up with all parties, high school guidance counselors, teachers as well as school guidance counselors. These groups will help with the sustainability of this effort.

Conclusions

Introducing foundational computer science courses like AP CSP takes more than just training the teachers. A conscious effort has to be given from all angles and all parties involved. School administrators also have to be supportive. The culture of computer science has to be introduced or improved, guidance counselors have to be educated and brought on board with the whole concept of offering foundational computer science. Guidance counselors, teachers as well as administrators have to be convinced of and committed to offering the foundational computer science courses.

Future Works

This is only the beginning of our attempt to increase enrollment in foundational computer science. Our plan in to continue this work and also to increase our geographic reach to include other parts of Florida.

The challenge we face is to make AP CSP part of the curriculum. The question that arises is, English is taught for 4 years in high schools, math is taught for 4 years in high schools, and many of the other science and subjects are taught at varying lengths, but why is computing not part of the regular high school curriculum? Efforts are being made at both the local as well as state levels to do this. Work has to continue until foundational computing can be made regular part of the curriculum for all high schools, and this is only the beginning.

Acknowledgements

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