CS for CT:
Examining the Landscape of Computer Science in Connecticut

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EXPANDING COMPUTING EDUCATION PATHWAYS

EXECUTIVE SUMMARY

Connecticut has made progress expanding and promoting Computer Science (CS) education across K-12. Due to efforts by teachers and administrators across K-12, the Connecticut State Department of Education (CSDE), higher education institutions, and non-profit, community, and professional organizations, students across the state have more opportunities to learn computer science, and at earlier ages than before. Additionally, there are more curricular resources available to teachers and schools interested in offering computer science. This progress is noteworthy and a positive development for the state.

However, while access to computer science education has improved, significant gaps and disparities exist. Specifically, achievement gaps in AP coursework between black and Hispanic students and their peers already exist. The authors identified the following four barriers to expanding CS education statewide and ensuring equitable access to computer science education:

- Shortage of Computer Science Teachers
- Unequal Access to Computer Science Education
- Difficulty in Defining Computer Science
- Difficulty in Measuring Student Participation

To address and overcome the barriers above, we offer the following recommendations to broaden participation in computing and ensure all students in Connecticut have access to high quality computer science education:

- Continue to grow the computer science education network in Connecticut and broaden and expand the coalition of K-12 educators
- Continue to expand professional development opportunities for computer science teachers including mentoring across districts
- Continue and support efforts by the CSDE to create pathways for teachers to become certified to teach computer science
- Ensure new K-12 Computer Science standards adopted by the CSDE are followed and implemented across the state
- Ensure the CSDE has accurate reporting of CS course completions
- Actively engage higher education institutions in the development of pre-service and in-service teacher trainings
- Actively engage industry to promote internships, apprentices, job-shadowing and other student work-based learning opportunities

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1. INTRODUCTION

The *CS for CT: Examining the Landscape of Computer Science in Connecticut* study was conducted to assess the current state of computer science education in K-12 and undergraduate levels across the state of Connecticut. The landscape study project team includes members of the CSDE Computer Science Advisory Committee (CSAC-CT), Expanding Computing Education Pathways (ECEP CT), and the Connecticut chapter of Computer Science Teachers Association (CTCSTA). The study was taken to support the *broadening participation in computing* goals of the ECEP Alliance and National Science Foundation (NSF). In assessing the current state of CS education, the study is designed to produce baseline and benchmark data that can guide policy and form a basis for further action and research.

This study identifies and analyzes trends in K-12 CS course participation and documents and summarizes challenges faced by computer science teachers within K-12 schools. The study analyzes trends in Advanced Placement (AP) Computer Science course participation, pass rates and student demographics. The study also incorporates information on the availability of teacher certification programs and CS student participation within higher education institutions in the state.

The study consists of the following components:

- Survey of K-12 Teachers, Administrators and Counselors
- Analysis of AP Course Ledger, AP Exam Participation and Success
- Post-Secondary Institutions and CS Teacher Certification
- Analysis of IPEDS higher education data
- Analysis of Secondary CS Course Enrollments

2. CONNECTICUT EDUCATIONAL CONTEXT

According to US News and World Report, Connecticut is ranked fifth overall in the nation for its Pre-K-12 education. This is based on scoring first for college readiness, third for preschool enrollment, and fourth for NAEP reading scores [20]. In 2017, Education Week’s annual report card placed Connecticut at sixth in the country, again based on the state’s ability to provide early foundation skills [21].

Despite the successes in Pre-K-12, Connecticut has one of the largest achievement gaps in English and Mathematics between low-income students and their peers [22]. Recognizing these existing gaps, the CSAC-CT identified ensuring access to quality computer science education for all students as a priority. Thus, this study is designed to assess the current state of K-12 CS education statewide, identify any disparities in access, participation, and success, and provide data to inform future advocacy and outreach work.

3. NEED FOR COMPUTER SCIENCE EDUCATION

The need for comprehensive K-12 computer science education for all students has been recognized and widely documented. [3, 4, 9, 23] All industries require employees with the ability to transcend disciplines, synthesize thought, and use these skills to solve both current and future problems. Nationally, the demand for employees with strong computational thinking skills far exceeds the current supply of students being graduated by the K-16 education system. Computer science education is the gateway to preparing students with these computational skills to be successful in college and career. This is one reason it is a social obligation to provide computer science education to all students.

Despite the numerous national initiatives underway to promote and expand access to computer science education the United States is not meeting national demand. From the United States Department of Labor Occupational Outlook Handbook, below is a partial list of the job descriptions directly returned on a "computer science" search.

Description	2016 Number of Jobs	Expected Growth	2016 Median Pay
Computer and Information Research Scientists	27,900	19%	$111,840
Computer Network Architects	162,700	6%	$101,210
Computer Programmers	294,900	-8%	$79,840
Computer Systems Analysts	600,500	9%	$87,220
Computer Support Specialists	87,100	10%	$52,160
Database Administrators	119,500	11%	$84,950
Information Security Analysts	100,000	28%	$92,600
Network and Computer Systems Administrators	391,300	6%	$79,700
Software Developers	1,256,000	24%	$102,280
Web Developers	162,900	13%	$66,130

Table 1: Partial List of Computer Science Occupational Outlook Data

From Table 1 above, the weighted average salary of graduates pursuing a job directly related to computer science is $90,510 and the projected growth is 13.8%. This estimate of demand is conservative, since it does not take into account the careers that do not exist yet or the careers called a name that is not directly related to computer science. In 2016, only 3.2 million people were employed in these fields. With the expected continued growth, we should be graduating 400,000 people into these careers.

While many people identify computer science as computer programming, computer programming is just one application of computer science. The study of computer science is much broader, involving problem-solving, communication, data analysis, algorithmic and computational thinking and much more. Table 1 provides evidence of the broad applications of computer science. Note that the jobs described as only

“Computer Programming” are showing decrease, but all other jobs related to computer science are showing growth.

Nationwide, the education system is not meeting these employment demands. In 2013, only 2.2% of SAT Test Takers intended to major in computer science [6]. The College Board 2017 National Summary Report, which summarizes the counts and demographics of AP Computer Science A and AP Computer Science Principles test takers, reveals the same. In the 2017 AP Computer Science A exam only 23.5% of exams were taken by women, only 11.6% by Hispanic students, and only 3.7% by black students. AP Computer Science Principles showed slight improvements with 30.1% of tests taken by women, 12.8% by Hispanic students, and 6.8% by black students. To put these statistics in context, 56% of all AP test takers are women, 23% are Hispanic/Latino, and 11.5% are black. More concisely, more than half of our population are either not provided access to or are opting out of AP Computer Science.

Similar evidence can be found from a 2016 Google and Gallup report [8] that found less than half of K-12 schools provide courses in programming and only 44% of seniors attend a school that has any computer science coursework listed. Overarching trends that stood out from the report were that (1) the larger the school, the more likely it is that the school supports computer science education and (2) access is improving as the computer science movement continues to take hold at the national level.

Previous studies have shed light on solutions. A parallel study by Google in 2016 [9] on diversity issues suggests that (1) computer science exposure before post-secondary education is crucial and (2) student confidence and awareness are top predictors of whether or not a student will continue their computer science education at the university level. The study found women are less likely than men to hear about opportunities to learn computer science either on the internet, in school, or locally. Women are less likely to have all three predictors: exposure, awareness, and interest. The study found that black students are more confident that white or Hispanic students, but are also less likely to have exposure to computer science education. Importantly, female, black, and Hispanic students are more likely to participate in computer science if encouraged by a community member, teacher, or other role model.

The need for computer science education in Connecticut mirrors the national need. State of Connecticut Department of Economic and Community Development (DECD) Commissioner Catherine Smith addressed this specific matter in a letter addressed to the Connecticut Conference of Independent Colleges (CCIC) in September 2017. Commissioner Smith stated, “Connecticut has 7000 open computing jobs but had only about 520 computer science graduates from its institutions of higher education”. Commissioner Smith describes the present situation in Connecticut with urgency. Commissioner Smith expresses support for comprehensive K-12 CS standards and requests higher education institutions across Connecticut prioritize and grow Computer Science programs to bolster and build the needed tech talent pipeline in Connecticut.

4. NOTABLE STATEWIDE EFFORTS TO BROADEN PARTICIPATION

Significant efforts have been undertaken since 2014 by advocates of K-12 Computer Science education to broaden participation and expand access to CS education. Numerous NSF-funded research projects within Connecticut have been undertaken such as:

- Math Science Partnership (MSP) Grant supported by Central Connecticut State University and Hartford Public Schools

- Mobile CS Principles (MobileCSP) [27] supported by Trinity College and local secondary schools

- Integrating Computer Science in the High School Biology, Chemistry, Earth and Energy Sciences Curriculum supported by Skills21 and EdAdvance [29]

In addition, Code.org has provided significant funding and support for K-5 teacher trainings in Connecticut. Code.org has also improved awareness and accessibility to computer science education through its Hour of Code initiative [28]. Code.org is also beginning to expand its efforts across the state in 6-12 teacher training.

The remainder of this section will focus on broadening participation activities undertaken by CTCSTA, CT-CSAC, and ECEP-CT [30].

Connecticut Computer Science Teachers Association

CTCSTA was formed in 2004 as an organization to support existing computer science teachers and became a chapter of the national CSTA in 2009. The chapter was formed during a period when many computer science teachers were isolated and there were few K-12 CS resources available. Since it's founding, CTCSTA has worked to grow and support computer science teachers. CTCSTA members are represented in numerous state organizations such as the CSAC-CT and ECEP-CT. Each of the grants and projects mentioned above have been supported by CTCSTA membership. Many CTCSTA members have also won significant national awards related to computer science advocacy.

CT State Department of Education Computer Science Advisory Committee

The CSAC-CT was formed in November 2014. The committee includes computer science teachers across K-12, higher-education CS faculty, representatives from CSDE, and industry, non-profit and community leaders. The committee was assembled to promote K-12 computer science education, determine needs statewide, and identify strategies to expand CS education across the state.

Initial activities undertaken by the committee included:

1) Attending assembly of Boards of Education and Superintendents to raise awareness of computer science education by encouraging all districts to participate in the Hour of Code. As a result of the Hour of Code movement created by Code.org, key members of the State of Connecticut education leadership, including superintendents, the Lieutenant Governor, and the Commissioner of Education have attended and encouraged Hour of Code events throughout the state.

2) Joining the Expanding Computing Education Pathways (ECEP) Alliance [23] as a participating state in 2015. ECEP is funded by the National Science Foundation to support broadening participating in computing.

3) Beginning formal data collection in support of this Landscape Survey at Connecticut STEM Conference, October 2016. This conference takes place annually at the Connecticut Science Center.

4) Drafting the *Position Statement on Computer Science Education for All Students K-12* detailing the importance of K-12 education in Connecticut and identifying key activities to be undertaken by various stakeholders. This Position Statement was adopted by the Connecticut State Board of Education (CSBE) in December 2016 [4].

SDE / DECD Computer Science Summits / CS4CT Summit 2018

Two Computer Science Summits were held during the 2016-2017 school year in February 2017 and May 2017. The summits were a joint effort at the CSDE and the DECD hosted by E.C. Goodwin Technical High School in New Britain, Connecticut. They included representation from the Department of Education, DECD, business groups, public and private educational systems, and national CS advocacy organizations. Educators from across K-12 and several certification areas, as well as higher education faculty participated. Participants shared successful models of expanding CS in other states, current efforts underway in Connecticut, and preliminary results from this Landscape Study. Summit participants were broken into subgroups to discuss, work through and draft preliminary goals and plans on issues such as teacher certification, CS curriculum, and funding.

In March 2018, CTCSTA hosted the Computer Science for Connecticut (CS4CT) Summit 2018. The CS4CT Summit brought together K-12 educators from across the state to promote and advance computer science education. The summit was designed to empower school districts across the state with resources and strategies to bolster CS education across all grade levels. A core focus of the summit was to promote equity in computing, such that all students across our state have access to high-quality CS education. Over 225 participants representing 78 school districts across the state participated [24]. A post-summit evaluation was conducted and completed by 110 of the summit participants. Table 2 contains a partial summary of participant feedback showing strong positive feedback regarding summit objectives.

Statement (110 Respondents)	% of Respondents that "Agree" or "Strongly Agree"
I better understand the importance of broadening participation in computing.	94%
I better understand the state of K-12 CS education in our state.	93%
I better understand the importance of K-12 CS education to support workforce/industry needs.	90%
I learned successful strategies other districts/schools have taken to teach CS.	77%
I learned valuable teaching practices to take back to my school/organization.	73%

Table 2: Partial Summary of Evaluation Data from CS4CT Summit 2018

New Graduation Requirements

The State of Connecticut provides guidelines for graduation requirements, but each school district makes decisions about how these guidelines are implemented at the local level [2]. Statewide graduation requirements have been update twice in recent years to encourage school districts to promote STEM (science, technology, engineering, and mathematics) coursework.

Graduation requirements for classes graduating in 2020 or later were adopted to encourage districts to move toward 8 credits in STEM. The requirements specified four credits in mathematics, three credits in science, and one credit in a STEM elective. Courses are specified in mathematics and science, but there is one credit in each that is open to district interpretation. In mathematics Algebra I, Geometry, Algebra II *or* Probability/Statistics are specified. No fourth mathematics credit is mandated. In science life science and physical science are specified with no third science credit being mandated. This leaves districts open to use computer science to fulfill graduation requirements in any/all of the mathematics, science, or the STEM electives.

Even newer requirements for classes graduating in 2023 or later have since been adopted to provide significantly more flexibility and options for school districts to count computer science coursework towards graduation. The newer requirements require each student to acquire nine credits in STEM.

K-12 Computer Science Standards

Representatives from CSAC-CT and CTCSTA formed a working group in Summer 2017 to develop new K-12 CS Standards for Connecticut. With representation across all grade levels, this group subdivided the work of reviewing and recommending CS standards for specific grade bands. Within each grade band, workgroup members considered the extent to which the State of Connecticut can support each standard, including identifying areas of need, recommendations for teacher support, and potential school districts to model successful implementation of the standards.

The workgroup voted to adopt the *CSTA K-12 Computer Science Standards*, *Revised 2017* [5] developed by CSTA. The draft standards were subsequently shared statewide for a review period and to collect stakeholder feedback. In June 2018, the CSBE adopted the new K-12 CS Standards [31]. The workgroup has also developed a guidance and resource document to support implementation of the new CS Standards within school districts.

K-12 Teacher Certification

In 2015-2016 members of the CSAC-CT represented Connecticut on an Educational Testing Service (ETS) panel to develop a new computer science Praxis Exam. Committee members continued to represent Connecticut, in conjunction with representatives from 25 other states, to develop the new Praxis Exam due to be released in September 2018.

Additionally, brainstorming and discussions on teacher certification were part of the two Computer Science Summits held during the 2016-2017 school year. The discussions largely focused on the use of badging for certification. In early 2018, CSDE initiated the exploration of pathways to teacher certification through an internal workgroup. This work remains underway and the workgroup is expected to be expanded to include external stakeholders.

5. CS FOR CT LANDSCAPE STUDY

5.1 SURVEY OF K-12 TEACHERS, ADMIINISTRATORS AND SCHOOL COUNSELORS

Methodology

The Connecticut Landscape Study team conducted a study of elementary, middle, and secondary schools in both the public and private education systems. In the study, the team collected information on teachers, such as the teacher's contact information, professional background and years teaching experience, and professional role. The study gathered feedback from teachers on the extent to which computer science is offered at their school, CS curriculum offered, student demographics in CS courses, resources used, and challenges to teaching and offering CS coursework.

Connecticut has 1647 schools: 754 public and private elementary schools, 522 public and private middle schools, and 371 public and private high schools. There are 206 school districts in total, 9 of which were classified as urban districts in the last census [12].

Recruitment of Survey Participants

Recruiting participants for the K-12 survey was initially challenging due to the difficulty identifying K-12 CS teachers across the state. This difficulty arises because CS is not a standard subject requiring teacher certification, so there is no statewide list of CS teachers. Additionally, CS teachers come from many backgrounds and reside in different academic departments within a school.

Recognizing this challenge, the study team used various strategies to identify and solicit participation. Initially, members of CTCSTA were recruited to participate in the survey through emails sent to the CTCSTA listserv. CTCSTA members also volunteered to recruit participants through setting up booths at the Connecticut STEM Conference and Connecticut Association of Boards of Education conference. Additionally, representatives from the CSDE emailed and included links to the survey in newsletters distributed to public schools. Multiple requests for participation were sent to both the CTCSTA and the State Department of Education listservs in three separate waves: January 2017, February 2017, and March 2017.

Participant Demographics

In March 2017 we reviewed the survey response rate and compared it to EdSight [13], a CSDE website that organizes and provides public access to a database of public school information. Our goal was 15% representation in each of the following subgroups: urban schools, public secondary schools, public middle schools, public elementary schools, private secondary schools, private middle schools, private secondary schools, magnet schools, charter schools, and technical high schools. Additionally we set a goal of 15% representation from Connecticut's two most populous Regional Education Service Centers (RESC), ACES (Area Cooperative Educational Services) and CREC (Capitol Region Education Council). In March 2017, we did not reach these goals in the following categories: private schools, public schools, magnet schools, charter schools, regional districts, endowed and incorporated, and technical high schools. We used a random number generator to randomly select schools in each category on EdSight, to meet the 15% goal. Then, through contact information on the school websites, we emailed the survey to points of contact at each school. Following this approach we had 133 responses by the end of March. We again checked against our desired representation and found that we still needed responses from private schools, public schools, magnet schools, charter schools, and technical high schools. Following the same approach, we sent another round of emails to points of contact in these schools. By the end of April 2017, we had over 200 unique schools represented in our survey. We reached our goal of 15% in almost every category except charter schools, private high schools, private middle schools, and private elementary schools.

Figure 1 shows the percent of participating schools in the survey, by each school category.

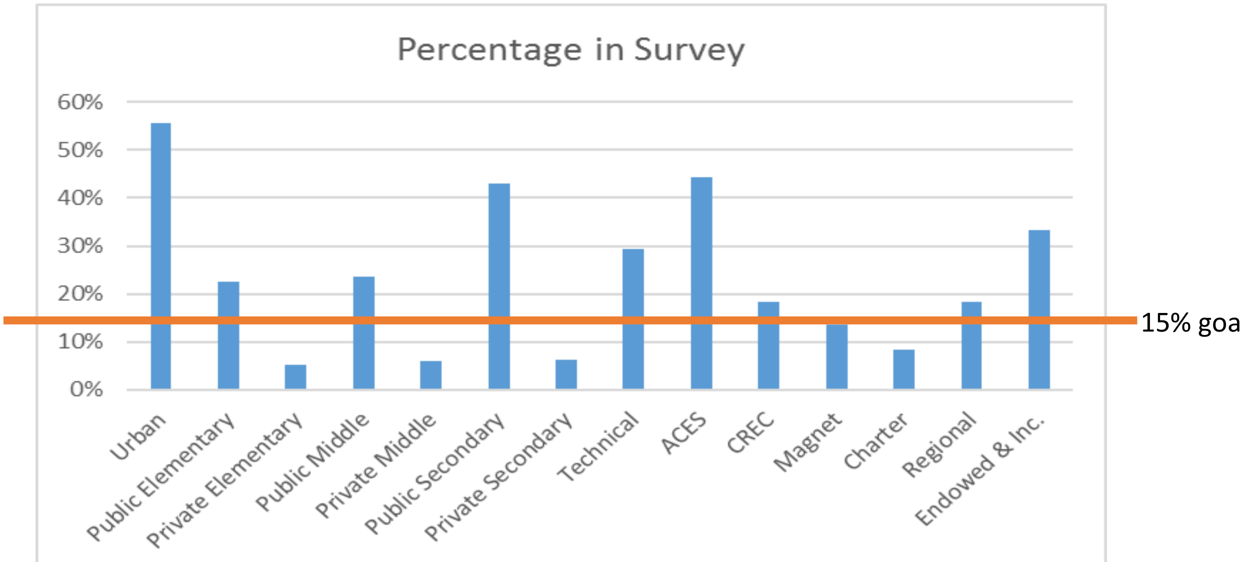

Figure 1: Percent of Participating School Categories in Survey

In total, we had representation from:

- 89 of 206 school districts
- 5 of 9 urban areas
- 117 of 522 public elementary schools
- 12 of 232 private elementary schools
- 65 of 275 public middle schools
- 15 of 247 private middle schools
- 68 of 158 public high schools
- 12 of 196 private high schools
- 6 of 17 technical high schools
- 4 of 9 ACES schools
- 6 of 18 CREC schools
- 2 of 126 magnet schools
- 2 of 24 charter schools
- 7 out of 388 program schools
- 17 out of 93 regional districts
- 1 out of 3 endowed and incorporated schools

Survey Instrument

The survey instrument we used was largely based on the survey instrument developed by the ECEP Maryland team in the study "CE21 Maryland, Powering Up Computing Education" [14] and the CSTA National Secondary Computer Science Survey. We adapted the survey to ask questions relevant to grade levels across K-12. We also added specific questions for administrators and school counselors, and separated questions for respondents based upon the respondents' role and grade level. We made changes to the list of challenges and factors and included both overlap and differences in this report.

The survey was created as a Google Form and administered via email. A total of 207 respondents completed the survey. The majority (75%) of respondents were teachers and/or department heads. The remaining survey respondents were administrators (22%) and school counselors (3%).

Results and Key Findings

a. Years of Computer Science Teaching Experience

CS teachers were asked to provide the number of years experience they have teaching computer science. Table 3 summarizes the responses from 156 survey respondents in Connecticut and compares to the responses to the CSTA National Survey.

Years of CS Teaching Experience	Connecticut (2017)	National (2015)
0	35.9%	1.9%
1-3	25.6%	25.3%
4-7	16.7%	9.3%
8-14	12.8%	12.2%
15+	9%	51.3%

Table 3: Years of Computer Science Teaching Experience

From the 156 respondents to this question**, 62% reported less than four years of CS teaching experience** and **36% reported less than one year of CS teaching experience.** These percentages are significantly higher than the results of the CSTA National survey. This has large implications for teacher professional development. It is essential that we provide training to support the growth of these new members of our computer science teachers' community.

b. Number/Demographic of Students Taking CS Coursework

The K-12 survey asked respondents to provide the number of students taking CS coursework, as well as the percentage of females and minority students in CS courses. Table 4 below merges the Connecticut Landscape Survey with National Data from the most recent CSTA Landscape Report [1]. Details about this table and key findings follow.

		Any CS Course		AP CS	
		Any CS (Connecticut, Landscape, 2017)	National Introductory (CSTA, 2015)	Any AP Course (Connecticut, Landscape, 2017)	National AP CS (2015)
Number of Students Enrolled	0	55%	11%	0%	0%
	1-10	1%	4%	28%	44%
	11-25	1%	25%	36%	36%
	26-50	1%	53%	19%	13%
	51-100	0%	11%	6%	6%
	101+	41%	7%	9%	2%
% Female	0%	53%	2%	49%	22%
	1-20%	9%	24%	9%	53%
	21-40%	12%	25%	14%	20%
	41-60%	24%	48%	23%	5%
	61-80%	0%	1%	0%	1%
% Minority	0%	59%	3%	63%	15%
	1-20%	27%	25%	28%	48%
	21-40%	1%	6%	3%	17%
	41-60%	1%	60%	3%	8%
	61-80%	1%	2%	3%	2%
	81-90%	0%	2%	0%	5%

Table 4: Percentage of Connecticut Students Compared to Nationwide Percentage in Computer Science

Notes on Table 4:

- The source for National counts of students for "Introductory" and "AP CS" was the 2015 CSTA Landscape Report [1]. Based on the percentages reported in this 2015 set, there was overlap between the two AP courses (AP CS A and AP CS Principles) so they are reported together in the AP CS Section.
- In the Connecticut survey, we did not have a question about whether or not a school taught Introductory Computer Science. For this reason, the left column of the table above is not an ideal comparison.
- An important difference between the CSTA Landscape study and the Connecticut Landscape Study is the population being sampled. We included teachers, administrators, and counselors and controlled questions to each. Therefore, several questions were not given to subgroups.

Key Findings from Table 4:

- Survey respondents in Connecticut were 5 times as likely to report no students enrolled in CS coursework. Fifty-five percent (55%) of respondents in the Connecticut survey indicate that no students take CS coursework of any kind (this includes AP). Compare this to the nationally where only 11% of respondents said no students take introductory CS courses.

- The majority of respondents indicated no females enrolled in Computer Science coursework. Fifty-three percent (53%) of respondents indicated that no females were enrolled in any computer science course (including AP). This far exceeds the percentage reported nationally (2%) for introductory computer science courses. Forty-nine percent (49%) of respondents indicated no female enrollment in their AP Computer Science coursework. This is also significantly higher than the national percentage reported (22%).

- The majority of respondents indicated no minority enrollment in Computer Science coursework. Fifty-nine percent (59%) of respondents indicated that no minority students were enrolled in any computer science course (including AP). This also far exceeds the percentage reported nationally (3%) for introductory computer science courses. Sixth-three percent (63%) of respondents indicated no minority student enrollment in their AP Computer Science coursework. This is also higher than the national percentage reported (15%).

Later in the CSforCT Landscape survey, respondents were asked specifically if the student population taking AP CS coursework is representative of their overall schools' population. Most respondents indicated that their AP Computer Science population is not representative of their school population.

- Eighty-six percent (86%) of respondents said that the percent female population was not representative of the overall female population.

- Forty-nine percent (49%) of respondents said that the percent minority population was not representative of the overall minority population.

Lastly, we reviewed the landscape survey responses to find correlation between teacher gender and student enrollment. In some states, such as the Maryland CE21 Report [14], there was evidence of the relationship between teacher gender and enrollment. In our study, we found no evidence of this relationship. Sixty-seven percent (67%) of teachers who responded to the survey were female; 33% were male.

c. Reasons Given for Not Offering Computer Science

The top four reasons (followed by the percent of respondents) stated in the survey for schools not offering computer science were as follows:

1) Budget restrictions (52%)
2) Lack of qualified teachers (35%)
3) CS is not a priority (25%)
4) CS is not a graduation requirement (18%)

d. Secondary - Topics Taught in Computer Science Courses

The following is a list of the most frequent topics indicated by respondents (followed by the percent of respondents):

1) Programming (96%)
2) Problem Solving (93%)
3) Ethics and Social Issues (63%)
4) Logic (63%)
5) Information about Computing/IT Careers (59%)
6) Hardware (54%)
7) Robotics (53%)
8) Graphics (51%)
9) Web Development (51%)

e. Secondary - Programming Languages/Software Tools Used in Secondary Computer Science Courses

The following is a list of languages and tools indicated by more than 35% of respondents.

1) Java (65%)
2) HTML (45%)
3) Scratch (39%)
4) App Inventory (38%)
5) JavaScript (36%)

f. Secondary - External Partnering Organizations for Teaching CS

Survey participants were asked an open-ended question to identify any outside vendor or organization their school partners with to teach CS. The majority of survey respondents identified Mobile CSP as a partnering organization. The next most common was Code.org, then "None" (or no outside source was needed). 83% of schools reported participating in Code.org's Hour of Code. Regarding implementation of AP CS Principles, Mobile CSP, Code.org, and Project Lead the Way were the only curricula named in this survey.

g. Secondary - Perceptions of Factors and Challenges to Offering Computer Science

Survey respondents were asked to identify factors for why secondary students do not take computer science courses. Below is a list of the common factors identified by the respondents, followed by the percentage of respondents that identified the factor as "Very Common" or "Somewhat Common".

1) Interest in other subjects (77%)
2) Students do not understand the importance (60%)
3) Subject matter is too hard (57%)
4) No room in schedule (54%)
5) Elective courses are less important (53%)
6) Perceived as male-dominated (37%)
7) Unaware the courses are offered (36%)
8) Limited job opportunities (6%)

The National CSTA Landscape Study asked similar questions in 2015. Respondents to this national survey listed the following factors for students not taking computer science. Again, these results are presented in order followed by the percent of respondents who stated that these factors were "Very Common" or "Somewhat Common".

1) No room in schedule (98%)
2) Interest in other subjects (97%)
3) Elective courses are less important (93%)
4) Subject matter is too hard (92%)
5) Perceived as male-dominated (89%)
6) Computer science is perceived as “geeky” (85%)
7) Limited job opportunities (67%)

In both the National CSTA Study and our study, “Interest in other subjects”, “Elective courses are less important”, “Subject matter is too hard”, and “No room in schedule” are common factors for why students do not take CS courses. In the 2015 CSTA Study, over 90% of respondents agree with these factors as leading causes. In both the 2015 CSTA study and our study “Limited job opportunities” was not a leading factor. In our study, only 6% of respondents identified this as a common factor.

h. Secondary - Factors in Teaching CS

Respondents were asked to consider several factors and estimate how big a challenge each factor was in teaching computer science in their school system. Below is a list of the common factors identified by the respondents, followed by the percentage of respondents that identified the factor as a “Great Challenge” or “Moderate Challenge”.

1) Inability to attract women and minorities (70%)
2) Lack of parental knowledge about the importance of computer science (69%)
3) Difficult subject matter (66%)
4) Lack of student interest/enrollment (64%)
5) Lack of parent encouragement for students to take computer science (62%)
6) Lack of guidance staff knowledge about computer science (59%)
7) Lack of student math preparation (55%)

Our results do not fully align with the National CSTA Landscape Survey [1]. The top five factors identified as a “Great Challenge” or “Moderate Challenge” by the National Survey are listed here:

1) Lack of student interest/enrollment (89%)
2) Difficult subject matter (89%)
3) Rapidly changing technology (87%)
4) Lack of support/interest by school staff (87%)
5) Lack of student subject knowledge (85%)

This is understandable because of the amount of resources that have been developed nationally over the past few years to make Computer Science accessible for more students.

Tables 5 and 6 were created to summarize overlapping categories and results for the Connecticut and National Surveys. The tables summarize factors and challenges that were choices in both surveys.

	Percentage of Respondents that Agree this is a Factor		Ranking of Factors Among all Responses (1 = most influential)	
Moderate/Significant Factor	Connecticut Landscape Study	National CSTA Landscape [1]	Connecticut Landscape Study	National CSTA Landscape [1]
Greater interest in other subjects	77%	97%	1 out of 7	2 out of 7
Electives are less important	54%	93%	5 out of 7	3 out of 7
Subject matter is too difficult	57%	92%	3 out of 7	5 out of 7
No room in schedule	54%	98%	4 out of 7	1 out of 7
Perception that field is male dominated	37%	89%	5 out of 7	5 out of 7
Limited job opportunities	6%	67%	7 out of 7	7 out of 7

Table 5: Factors in Offering Computer Science in Connecticut

	Percentage of Respondents that Agree this is a Challenge		Ranking of Challenges Among all Responses (1 = most influential)	
Very/Somewhat Common Challenge	Connecticut Landscape Study	National CSTA Landscape [1]	Connecticut Landscape Study	National CSTA Landscape [1]
Lack of hardware/software resources	39%	74%	13 out of 15	8 out of 8
Lack of curriculum resources	42%	82%	12 out of 15	7 out of 8
Lack of teacher subject knowledge	49%	83%	10 out of 15	6 out of 8
Lack of support/interest by school staff	46%	87%	11 out of 15	4 out of 8
Lack of student interest/enrollment	64%	89%	4 out of 15	1 out of 8
Difficult subject matter	66%	89%	3 out of 15	2 out of 8
Rapidly changing technology	53%	87%	8 out of 15	3 out of 8

Table 6: Challenges in Offering Computer Science in Connecticut

i. Middle School (6-8) Response Summary

The following bullets summarize responses from 6-8 schools:

- The top three topics taught are: (1) Problem Solving (77%), (2) Programming (73%), and (3) Ethics and Social Issues (59%).
- The top three tools were: (1) Scratch (56%), (2) HTML (44%), and (3) JavaScript (33%)
- The top resources listed were: (1) Code.org (75%) and (2) Scratch (56%)
- The greatest challenges for middle school teachers reported in an open-ended prompt were: (1) the middle school schedule means that time with students in specials is reduced, (2) cost of purchase and maintaining technology, and (3) the need for training.

Note that this study was administered before Code.org released its CS Discovery Courses for Middle School and Google CS First was not highlighted in the survey.

j. Elementary School (K-5) Response Summary

The following bullets summarize responses from K-5 schools:

- The majority (71%) of elementary school computer science education happens during specials or a "Unified Arts" block.
- The top three topics taught are: (1) Programming (83%), (2) Problem Solving (72%), and (3) Robotics (39%).
- The top three resources are: (1) Code.org (89%), (2) LightBot (56%), and (3) Scratch (50%).
- The greatest challenges for elementary school teachers reported in an open-ended prompt were: (1) the need for more time, (2) the need for professional development, and (3) a way to connect computer science to other courses and grade levels

5.2 ANALYSIS OF AP COURSE LEDGER, AP EXAM PARTICIPATION AND SUCCESS

The Landscape Study Team reviewed the AP Course Ledger [15] to identify secondary schools across Connecticut teaching AP Computer Science. The AP Course Ledger lists secondary institutions worldwide authorized to include the AP Designation for courses listed on student transcripts. Schools elect to complete this process, and it is important to note that some schools do offer AP Coursework without the AP designation and other schools have additional requirements such as attending College Board Training before a teacher can teach an AP Course. This findings here are from the AP Course Ledger in February 2017.

In addition, the study team analyzed student participation and pass rates in AP Computer Science Courses. This data was obtained from the College Board website.

Methodology

For the AP Course Ledger results, each secondary institution in Connecticut was accessed on the AP Course Ledger to determine if the school had an AP Teacher authorized to teach AP Computer Science A, AP Computer Science Principles, or both courses. In total, 279 secondary schools were verified, which is approximately 79% of the 354 total secondary schools in the state of Connecticut according to EdSight.

AP score results for students across Connecticut taking the Computer Science A and Computer Science Principles AP exams were downloaded from the College Board website [7] for the years 2010 through 2017.

Results

Of the 279 schools, 28.3% of schools had AP Computer Science A listed on the ledger, 18.6% had AP Computer Science Principles, and 9.3% of schools had both. Eighty-one (81) teachers were listed as AP Computer Science A Teachers, and 64 were listed as AP Computer Science Principles Teachers.

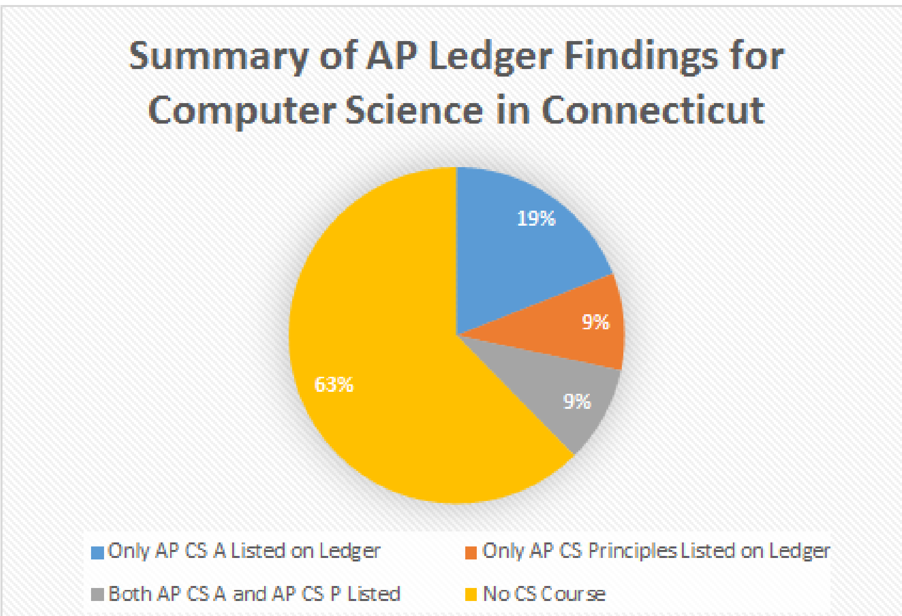

Figure 2: Summary of AP Ledger Findings for CS in Connecticut

Participation in AP Exams and Results

	Computer Science A	Computer Science Principles	Physics I	Biology	Calculus AB	English Language & Composition
2015	648	*	2770	3831	4528	7037
2016	939	*	2766	3967	4489	7314
2017	983	889	2936	3896	4313	7267

Table 7: Connecticut AP Exam Participation By Subject

***** Computer Science Principles is a new AP course first offered in 2017. The course was specifically developed to broaden participation by making computer science coursework more accessible.

	Computer Science A								Computer Science Principles
	2010	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2017**
% of Male Test-takers	80%	84%	83%	81%	78%	76%	77%	77%	69%
% of Female Test-takers	20%	16%	17%	19%	22%	24%	23%	23%	31%

Table 8: Connecticut CS AP Exam Participation By Gender

# of Participants	Computer Science A								Computer Science Principles
	2010	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2017**
Asian	66	67	90	100	148	153	197	230	174
White	251	189	267	304	414	407	584	604	532
Hispanic/Latino	19	15	28	22	33	36	76	61	85
Black	10	12	17	11	20	15	31	32	51
Total	373	298	436	460	642	648	939	983	889

Table 9: Connecticut CS Exam Participation By Ethnicity

% of Participants Score 3 or higher	Computer Science A								Computer Science Principles
	2010	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2017**
Male	58%	71%	59%	69%	62%	68%	70%	72%	85%
Female	60%	71%	67%	63%	63%	70%	64%	74%	81%

Table 10: Connecticut CS Exam Pass Rate by Gender (Pass is Score of 3 or higher)

% of Participants Score 3 or higher	Computer Science A								Computer Science Principles
	2010	2011	2012	2013	2014	2015	2016	2017	2017
Asian	74%	82%	68%	69%	70%	73%	72%	76%	87%
White	57%	71%	63%	69%	60%	70%	70%	76%	88%
Hispanic/Latino	32%	33%	36%	59%	58%	42%	57%	51%	64%
Black	40%	42%	41%	55%	55%	53%	52%	34%	63%

Table 11: Connecticut CS Exam Pass Rate by Ethnicity (Pass is Score of 3 or higher)

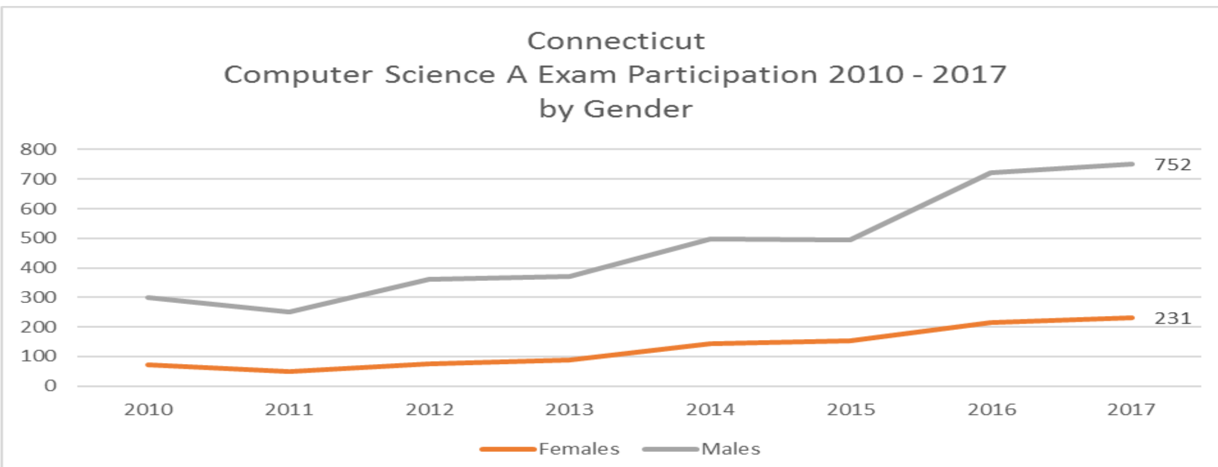

Figure 3: Connecticut CS A Exam Participation by Gender

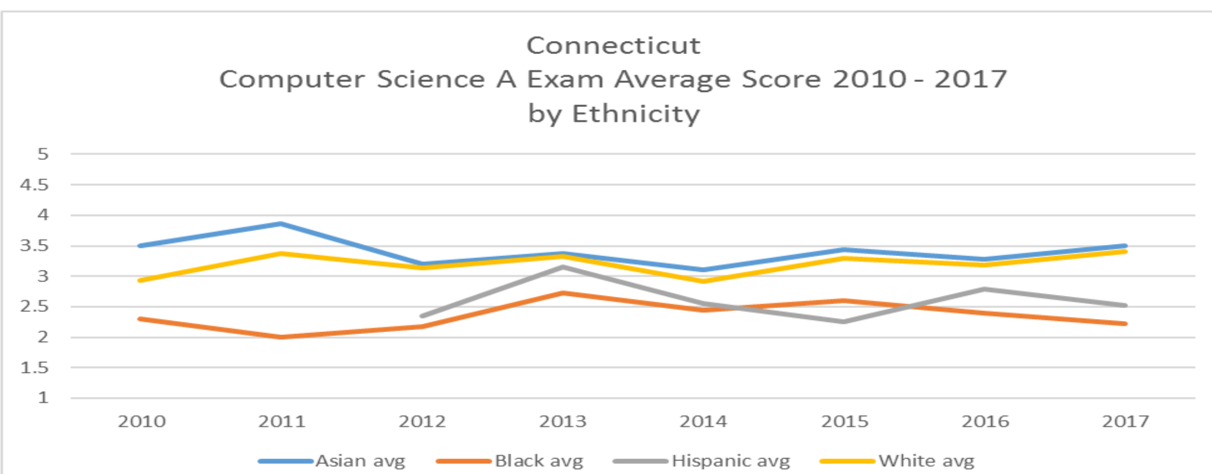

Figure 4: Connecticut CS A Exam Participation by Ethnicity

Key Findings:

- As shown in Table 7, the number of students taking the AP CS exams, while increasing, is significantly lower than the number of students taking other core AP subject areas. Clearly, increased access to CS coursework is needed.

- As shown in Table 8, between the years 2010 and 2017, around 20% of CS A exam test takers were female. During that same time period, Table 10 shows female test-takers performed at the same level on CS A exam despite being such a a small percentage of test-takers. This suggests that improved access for females will lead to increased success. Female test-takers also performed at the same level for the first administration of CS Principles, which had increased female participation.

- As shown in Tables 9 and 11, black and Hispanic students are not participating at the same levels as students from other races. Additionally, the few black and Hispanic students who are participating are passing the exam at lower rates. These results demonstrate an achievement gap that needs to be addressed.

- According to Tables 8 and 9, the emergence of AP CS Principles in 2017 has led to improvement in the participation and pass rates of black, Hispanic and female students. The increase in pass rates is particularly noteworthy for black students. These results are promising and we are optimistic that this participation in AP CS Principles will lead to improved participation and scores in AP Computer Science A.

- While Figure 3 shows an increase in male participation for AP Computer Science A, it also highlights the discrepancy between male and female test takers. It is concerning that females have not seen any significant increase in participation.

5.3 POST-SECONDARY INSTITUTIONS WITH FOCUS ON TEACHER CERTIFICATION

The Landscape Study Team conducted an analysis in June 2015 to determine the number of colleges or universities in the State of Connecticut that both satisfy teacher training requirements and offered computer science. This analysis followed a meeting of CSAC-CT where committee members inquired about universities best positioned to support teacher trainings in computer science.

Methodology

The study looked at the websites for 41 Colleges and/or Universities in the State of Connecticut. Every website of these 41 schools was visited to look for evidence of (1) teacher certification programs and (2) computer science.

Results

Of these 41 schools, 21 (or about 51%) offered courses in computer science. Of the universities or colleges that offered computer science they housed these courses under the following departments or categories: (1) computer information systems, (2) technology studies, (3) information systems, (4) computer engineering, (5) engineering technologies, (6) engineering, and (7) mathematics. Of these 41 schools, 14 of the schools (34%) offered coursework in education. Some of these schools did not have education programs that led to certification to teach in public schools. These schools also varied in population impact as shown below.

The following chart shows the colleges with the largest percentage of students in attendance. Note that the 14 colleges and universities shown here make up 72% of the state undergraduate student population.

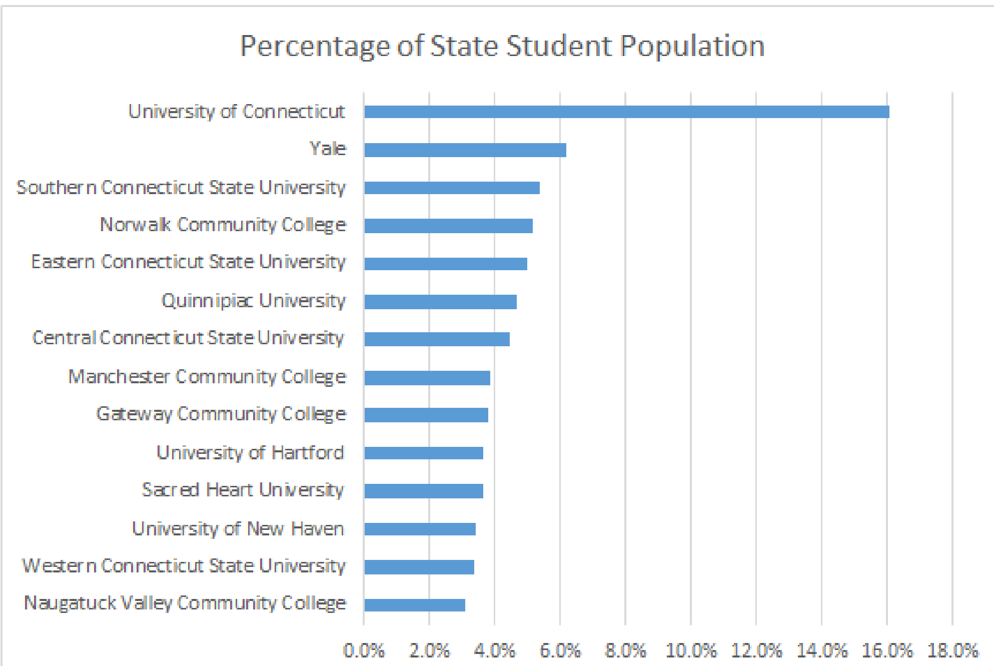

Figure 5: Colleges with the Largest Percentage of Connecticut Students in Attendance

5.4 ANALYSIS OF INTEGRATED POSTSECONDARY EDUCATION DATA SYSTEM HIGHER EDUCATION DATA

The Landscape Study Team analyzed NCES (National Center for Education Statistics) undergraduate data to investigate demographics of computer science majors across institutions of varying types [26]. For this study, CS majors were determined by searching for completers using the Computer and Information Sciences CIP code. Completions in the code Computer and Information Sciences CIP code were charted to compare degree completions by gender and ethnicity between the years 2010 and 2016.

Results

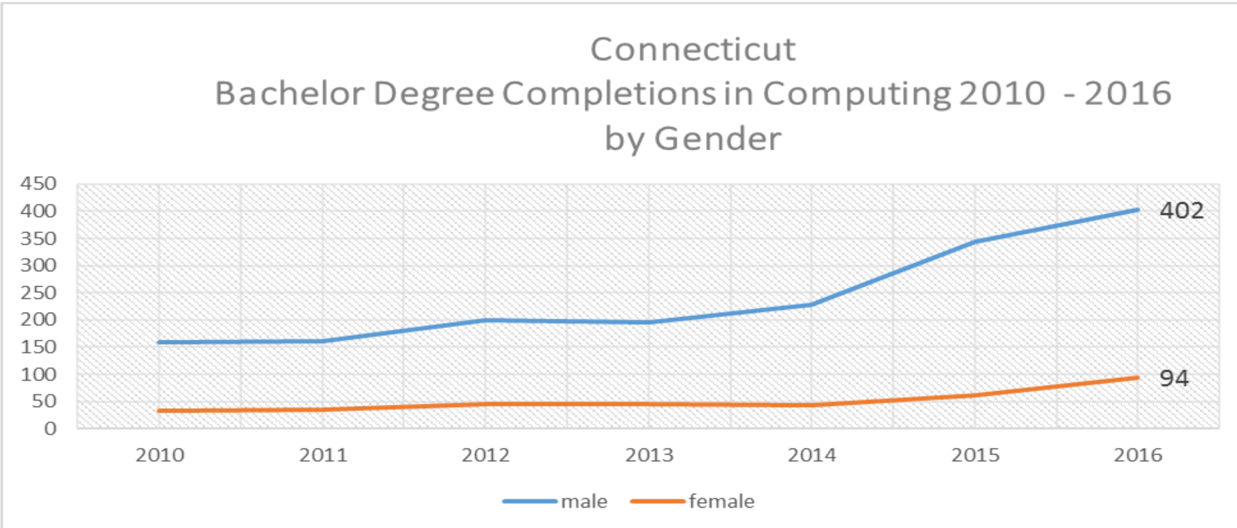

Figure 6: Connecticut Bachelor Degree Completions in Computing by Gender

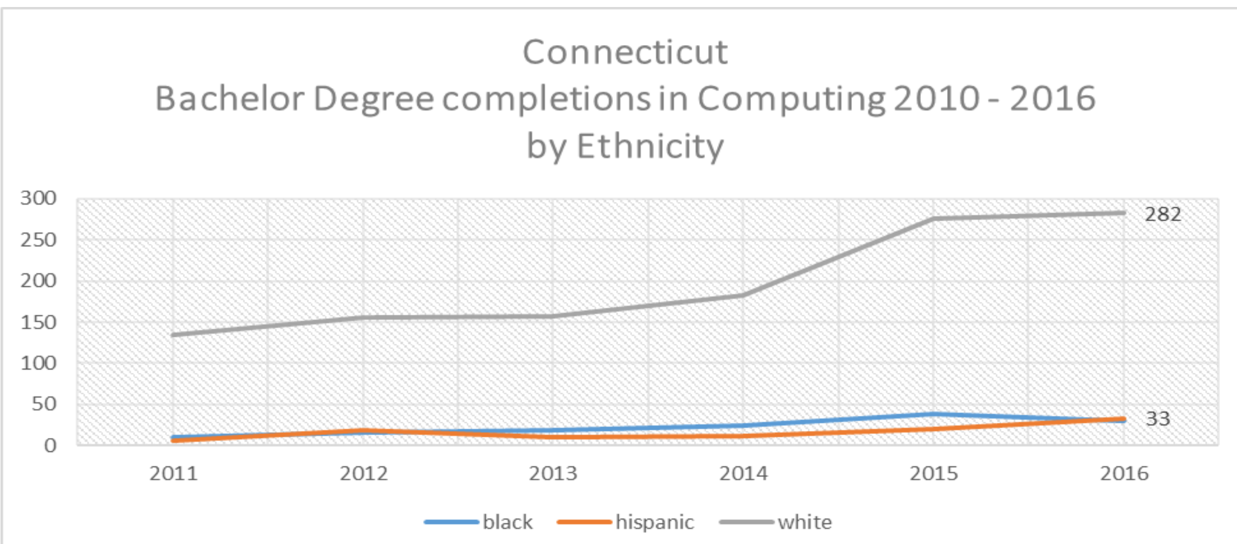

Figure 7: Connecticut Bachelor Degree Completions in Computing by Ethnicity

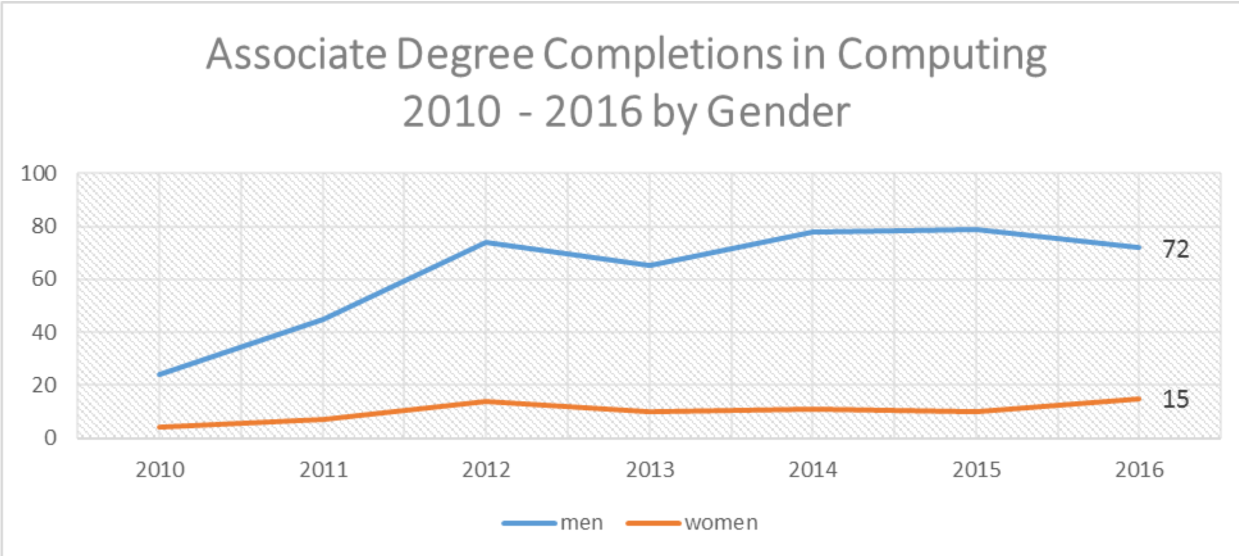

Figure 8: Connecticut Associate Degree Completions in Computing by Gender

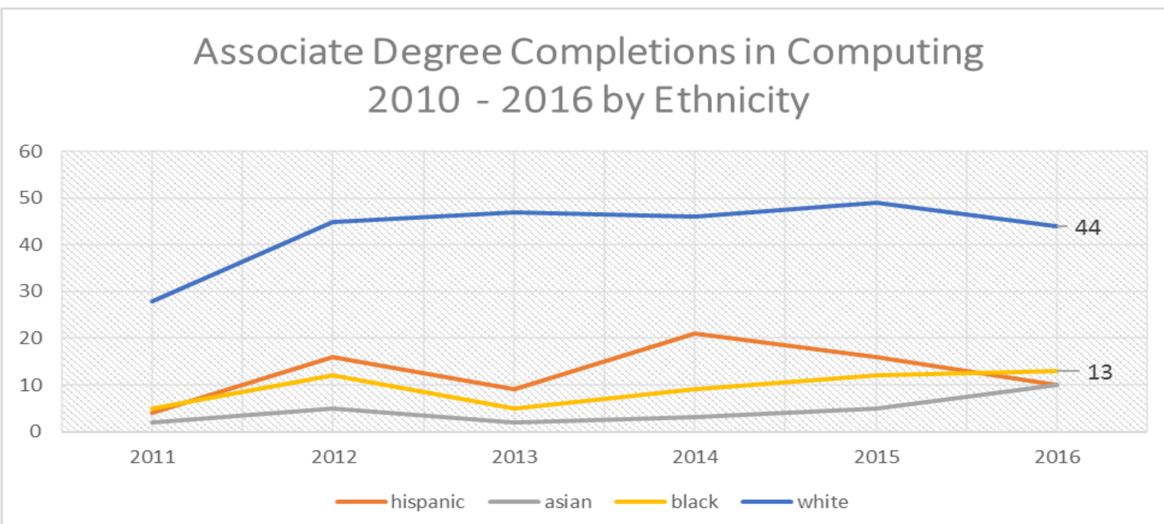

Figure 9: Connecticut Associate Degree Completions in Computing by Ethnicity

Key Findings:

- Figures 6 and 8 highlight the gaps between male and female students completing bachelors and associates degrees, respectively. While there has been an increase for male students, there has not been an increase for female students.

- In Figures 6 and 8, only 20% of bachelors degrees were completed by females. This is percentage is even lower for associate degrees, where 15% were completed by females.

- Figures 7 and 9 also show the gaps between white students and black and Hispanic students completing bachelors and associates degrees, respectively.
- Reflected in Figures 6-9 are the low numbers of students completing bachelors or associate degrees. The number of graduates is way too small to meet the industry need for CS graduates.

5.5 ANALYSIS OF SECONDARY COMPUTER SCIENCE COURSE ENROLLMENTS

The Landscape Study Team sought to identify where computer science is being taught across secondary schools in Connecticut. Specifically, the team sought to identify computer science course enrollments across school districts. To support our research, we used the CSDE EdSight reporting tool.

Methodology

EdSight has course information listed by district under for the 2013-2014, 2014-2015, and 2015-2016 school years. The website also provides tools that allow you to download data from all three years at the same time to investigate trends. From the time we began this study, the EdSight tool evolved to potentially provide much of the data we were trying to determine from our survey, but in more detail. According to data.ct.gov [16], EdSight "integrates information from over 30 different sources – some reported by districts and others from external sources". It is part of the Socrata Open Data API [17]. All data referenced here are from the most recent update (May 2017).

Table 11 below shows the search input and data set names used for this analysis.

Summary of Search	Districts	Schools	Year	File name
Course Enrollments by Subject, Trend, all grades, Subject: Computer and Information Sciences, All Categories, All Courses	All	All	2013-2016	courseEnrollmentsbySubject
Student Counts by School and English Learner Status	All	All	2016-2017	enrollmentELL
Student Counts by School and Free/Reduced Lunch Eligibility	All	All	2016-2017	enrollmentFreeRed
Student Counts by School and Gender	All	All	2016-2017	enrollmentGender
Student Counts by School and Race	All	All	2016-2017	enrollmentRace
Student Counts by School and Special Education Status	All	All	2016-2017	enrollmentSPED
School Counts by School and Year	All	All	2016-2017	enrollmentSingleYear

Table 11: Search inputs and data set names for EdSight Analysis and Demographic Analysis

Results

Table 12 shows the dominant categories for Computer and Information Sciences for Schools and Districts in Connecticut.

Category	Percentage of Schools Reporting this Category	Percentage of Districts Reporting this Category
Computer Literacy	56%	87%
Media Technology	25%	6%
Computer Programming	13%	4%

Table 12: Dominant Categories for Computer and Information Sciences for Schools and Districts in Connecticut

Note that the Computer and Information Sciences Search included 62 unique course names and 7 unique categories. Of the 62 course names, the most common course names, with the percentage of schools that reported offering each is reported here:

- AP Computer Science A (17%)
- AP Computer Science AB (11%)
- Area Network Design and Protocols (10%)

The study team also downloaded trend data for the 709 schools and 171 districts over the following three years: 2013-2014, 2014-2015, and 2015-2016. While clear trends were identified, the team decided against highlighting the trends because of inconsistencies in the data reported on this site. The study team cross-referenced course enrollment data on EdSight with specific school catalogs and noticed incorrectly coded CS courses, and CS courses that were missing. This unfortunately severely limited how we used the EdSight tool. As one of our recommendations in this study, it is critical school districts are supported with this resource to ensure correct classification and recording of CS courses.

6. CONCLUSIONS & RECOMMENDATIONS

Significant progress is being made in Connecticut advancing computer science education. Many teachers, school counselors, district and school administrators recognize the importance of computer science education. They recognize how computer science education helps students become college and career ready. They understand and articulate the importance of providing access to all students in a timely manner so achievement gaps in this area do not develop or widen.

Additionally, numerous non-profit, community and professional organizations have been and continue to work hard to advocate for K-12 CS education and support CS teachers across K-12. Higher education institutions across the state are leading research efforts and partnering with specific school districts and schools to support teachers and increase student participation. The CSDE and CSBE have demonstrated clear support through the *Position Statement on Computer Science Education for All Students K-12* as well as leadership and guidance to school districts through the recently adopted K-12 CS Standards.

Finally, it is noteworthy that progress within schools and districts has been made without legislative mandates or large-scale state funding. Some school districts and individual schools are moving forward due to a strong commitment on behalf of teachers and administrators to prepare their students with foundational, in-demand computational thinking skills. However, as reflected by the underrepresentation of females and minority students in secondary CS courses and the existing achievement gaps in AP coursework, there is significant work that needs to be done.

Barriers to Expanding K-12 CS Education

Despite areas of progress within some schools and districts, the study team identified significant challenges facing the state as a whole in expanding CS education. The following factors were identified as the primary barriers to broadening participation and expanding computer science access:

Shortage of Computer Science Teachers

There is a shortage of qualified teachers in Connecticut to teach computer science. Many teachers in the K-12 survey specified this as a reason to not offer computer science courses. There is currently no pathway for aspiring educator in science, technology, engineering, or mathematics to pursue certification in computer science, nor a mandated score on the Praxis exam for Computer Science. The work underway by the CSDE to develop certification pathways is critical to begin to address this shortage.

Unequal Access to Computer Science Education

Access to computer science education is neither systematic, nor is it consistently applied across the 206 districts and 1647 public and private K-12 schools. There are several reasons for this disparity, many of which were cited in the 2015 National CSTA Survey: rapidly changing technology, lack of curriculum/ resources, and lack of support/interest by school/staff [1]. These same challenges to offering CS coursework were reported by educators in Connecticut in the K-12 Survey. Ensuring students can fit CS coursework into their class schedule, and allowing multiple options for CS coursework, are important steps as well.

Difficulty in Defining Computer Science

In both the K-12 survey responses and the mapping of courses to CIP codes in EdSight, it is apparent that lack of standardization has led to different understandings and definitions of CS. This difficulty and inconsistency in defining what computer science is, hinders school districts and schools from providing comprehensive CS curriculum. The lack of K-12 CS standards also makes it difficult to align CS curriculum across grade-bands. With the adoption of K-12 Computer Science Standards by the CSBE this factor should begin to be alleviated as districts use these standards to guide their course offerings and alignment.

Difficulty in Measuring Student Participation

Through this study, limitations in the EdSight tool hindered the ability to identify which school districts and specific schools teach CS. Through comparing the EdSight results with specific schools, it became clear that CS courses were incorrectly coded and some courses missing. Work needs to be done to ensure correct classification of CS courses to ensure advocacy efforts reach districts and schools in need.

Recommendations

Through this study, it is clear that the lack of access to CS education and participation in CS courses at secondary levels leads to the same disparities in participation by gender and ethnicity in undergraduate CS degrees. To remove these disparities efforts must be focused earlier in K-12. Students throughout Connecticut must be taught CS and understand why the study of CS is important. There needs to be a significantly larger pipeline of students taking CS courses in secondary schools.

To move towards the goal of computer science for all students in Connecticut, both the State of Connecticut and school districts across the state need comprehensive, long-term plans to successfully implement computer science at all grade levels. Significant work has been done in the areas of K-12 curriculum development and K-12 CS standards. A sustainable, long-term effort is needed, however, for this work to take traction statewide. To make traction, the authors make the following recommendations:

(1) Continue to grow computer science education network in Connecticut and broaden and expand the coalition of K-12 educators

(2) Continue to expand professional development opportunities for computer science teachers including mentoring across districts

(3) Continue work with the State Department of Education to create pathways for teachers to become certified to teach computer science

(4) Ensure new K-12 Computer Science standards adopted by the CSDE are followed and implemented across the state

(5) Ensure the CSDE has accurate reporting of CS course completions

(6) Actively engage higher education institutions in the development of pre-service and in-service teacher trainings

(7) Actively engage industry to promote internships, apprentices, job-shadowing and other student work-based learning opportunities

Future Study

As educators and advocates continue work to expand access to CS education across Connecticut, future research and study is needed to identify where and how access to CS education is changing and how CS teaching is improving. To do so, the study team recommends repeating the K-12 survey in two years to see how feedback from teachers, school counselors and administrators is changing. Along with this, the study team recommends utilization of EdSight to track CS course completions across schools and districts. This requires current and accurate data from EdSight which is critical for any future analysis.

A related area of future study is to measure the effect of early exposure to CS education on student participation and success in CS coursework at the secondary level. The goal is for school districts to successfully integrate CS earlier into elementary and middle school, and align curriculum at all levels with the new K-12 CS standards. Studies that measure and show effective models of implementation will be a great resource to be shared with CS educators across the state.

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RESOURCES

[1] "CSTA National Secondary School Computer Science Survey 2015". *CSTA – High School Computer Science Surveys.* https://c.ymcdn.com/sites/www.csteachers.org/resource/resmgr/Docs/Research/HSSurveys/CSTA_NATIONAL_SECONDARY_SCHO.pdf

[2] CSDE, "*Connecticut General Statutes 10-221a*.". https://www.cga.ct.gov/2015/act/pa/2015PA-00237-R00SB-01059-PA.htm

[3] ACM/CSTA, "*Running on Empty*". http://runningonempty.acm.org/

[4] CSDE, *"Position Statement on Computer Science"*. http://www.ct.gov/ecd/lib/ecd/tech_talent_fund/computer_science_position_statement.pdf

[5] *Computer Science Teachers Association (CSTA) K-12 Computer Science Standards*, https://www.csteachers.org/page/standards

[6] College Board, *SAT Total Group Profile Report,* http://media.collegeboard.com/digitalServices/pdf/research/2013/TotalGroup-2013.pdf

[7] College Board, *National (and State) Summary Reports,* https://research.collegeboard.org/programs/ap/data/participation/ap-2017

[8] Google, *Trends in the State of Computer Science in US K-12 Schools,* http://services.google.com/fh/files/misc/trends-in-the-state-of-computer-science-report.pdf

[9] Google, *Diversity Gaps in Computer Science: Exploring the Underrepresentation of Girls, Blacks, and Hispanics*, http://services.google.com/fh/files/misc/diversity-gaps-in-computer-science-report.pdf

[10] BNY Mellon, *State of States Landscape Report: State-Level Policies Supporting Equitable K-12 Computer Science Education*, https://www.ecs.org/ec-content/uploads/MassCAN-Full-Report-v10.pdf

[11] *Association for Computing and Machinery, Rebooting the Pathway to Success.* http://pathways.acm.org/ACM_pathways_report.pdf

[12] *US Census*, https://www.census.gov/prod/cen2010/cph-2-8.pdf

[13] EdSight, CSDE, http://edsight.ct.gov/SASPortal/main.do.

[14] *CE21 Maryland.* "Powering Up Computing Education", https://dl.acm.org/citation.cfm?id=2445402

[15] *AP Course Ledger*, College Board, 10 Feb. 2017, https://apcourseaudit.epiconline.org/ledger/

[16] "EdSight – State education data repository | Open Data – State of Connecticut.". *State of Connecticut – Open Data, data.ct.gov/Education/EdSight-* https://data.ct.gov/Education/EdSight-State-education-data-repository/7uts-qap4

[17] "Puts "Hello Data!";" *Socrata Developers|Socrata*, https://dev.socrata.com/

[18] *Connecticut Computer Science Teachers Association*, http://www.ctcsta.org/

[19] *Computer and Mathematical Occupations, Employment Projections (2014-2024)*, CTDOL, https://www1.ctdol.state.ct.us/lmi/projections2014/computers.asp

[20] "Connecticut Ranks No. 5 for Pre-K-12 Education Among U.S. States." *U.S. News & World Report*, usnews.com/news/best-states/Connecticut. https://www.usnews.com/news/best-states/connecticut

[21] "Quality Counts 2017: State Report Cards Map", *Education Week*, https://www.edweek.org/ew/qc/2017/2017-state-education-grades-map.html

[22] U.S. Department of Education, NAEP Data Explorer. http://nces.ed.gov/nationsreportcard/naepdata/

[23] Expanding Computing Education Pathways, ECEP Website, https://ecepalliance.org

[24] CS4CT Summit 2018 Website, CS4CT Website, http://www.ctcsta.org/cs4ct/

[25] Counselors for Computing Website, https://www.ncwit.org/project/counselors-computing-c4c

[26] National Center for Education Statistics, https://nces.ed.gov/ipeds/

[27] Mobile CS Principles Website, http://www.mobile-csp.org/

[28] Hour of Code Website, https://hourofcode.com/us

[29] EdAdvance Website, http://edadvance.org/schools-districts/skills21

[30] ECEP Alliance Connecticut Website, https://ecepalliance.org/connecticut-0

[31] Connecticut Computer Science Standards Approved, https://portal.ct.gov/-/media/SDE/Digest/2017-18/Adoption-of-the-CSISTE-Standards-Supers-Memo-and-CS-memo-(002).pdf?la=en