CE21 MARYLAND

Powering Up Computing Education

Full Report

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CE21–Maryland[1]

Rebooting Computing Education in Maryland High Schools

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EXECUTIVE SUMMARY

STEM education initiatives are a visible priority in Maryland. Governor Martin O'Malley has declared that "preparing our children for the knowledge-based economy is among our highest priorities as we seek to improve STEM training throughout the state." Even with this level of commitment and effort, the supply of Maryland workers with the necessary computing skills is well below demand. By 2018, there will be an estimated 40,000 new computing-related jobs available in Maryland each year, yet only approximately 2,000 bachelor's degrees in computing and information systems are awarded by Maryland institutions annually. Efforts are needed to broaden the pipeline of students from all backgrounds who are ready to study computing beyond high school.

Maryland's public education system has been ranked number one in the nation for the past three years. Maryland has consistently earned high grades for providing opportunities for success on Education Week's annual education report card and ranks first for the percentage of graduating seniors who have taken AP exams in math and science. Despite these accolades and sustained commitment to STEM education, there has been little focus on or progress in computer science education specifically. Maryland does not require computer science as a graduation requirement and teacher certification is not required for teachers of CS classes. As a result, the vast majority of students leave high school without exposure to computational thinking skills, programming knowledge, or information about career opportunities in computer science and IT fields.

Tremendous variability exists among school systems and among high schools within systems in terms of the opportunities available to students to study computer science. Maryland public school system enrollments are diverse, yet women, African Americans, and Latinos are still underrepresented in undergraduate computing programs in Maryland, reflecting national statistics. It is no surprise, then, that even the most successful high school graduates arrive at college uninterested in and unprepared to study computer science. With funding from NSF's Computing Education for the 21st Century (CE21) Program, the CE21–Maryland research team seeks to directly address this problem. The project is focused on two main activities: (1) gathering data about the status of CS education in Maryland high schools and (2) building relationships among high school teachers, community college and university faculty, and state education administrators to facilitate and increase state-level support for lasting improvements to computing education.

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[1] Some material in this report has been adapted from a paper to be published in the 44th ACM Technical Symposium on Computer Science Education (SIGCSE-13) ("CE21—Maryland: The State of Computer Science Education in Maryland High Schools," Marie desJardins and Susan Martin).

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UMBC is a leader in STEM education and in issues related to women and underrepresented minorities in STEM fields. Recent efforts by UMBC's Department of Computer Science and Electrical Engineering (CSEE) and the Center for Women in Technology (CWIT) to improve high school computer science education in Maryland have included two Google-sponsored CS4HS workshops for high school computer science teachers and the founding of a Maryland chapter of the Computer Science Teachers Association (CSTA). Evaluation data from both workshops revealed that the teachers who attended benefited greatly from networking with other computer science teachers, significantly increased their knowledge about national and state computer science education issues, and were eager to participate in future computer science related professional development opportunities.[3]

UMBC's CE21–Maryland planning project began in March of 2012. An online survey of Maryland high school computer science teachers was conducted in May 2012 and a computer science education mini-summit was held at UMBC for 50 teachers, faculty, and administrators in August 2012. Planning is underway for the culminating statewide computer science education summit, to be held at UMBC on May 17, 2013.

Recommendations:
Based on the data from our survey and our community building experiences, we have identified four concrete recommendations to focus the CS education community's efforts in Maryland:

1. Continue to grow the computer science education network in Maryland.
2. Educate the broader community about the CS education crisis.
3. Increase the availability of high-quality CS courses for all Maryland high school students.
4. Provide effective professional development opportunities and develop certification programs to expand the number of highly qualified high school CS teachers.

The remainder of this report provides an overview of the challenges in CS education nationally and in Maryland, summarizes our findings from our CS teacher survey, summarizes our community building efforts, and expands upon the recommendations listed above.

1. INTRODUCTION

Despite the overall success of Maryland's K-12 education system, opportunities to study computer science vary tremendously among the 24 school systems and 247 high schools in the state. This disparity can be attributed to a number of the factors previously identified by two Computer Science Teacher Association (CSTA) surveys: lack of a state-mandated computer science high school graduation requirement, no state-required teacher certification in the discipline, and the absence of a standardized computer science curriculum [6]. Many of these factors exacerbate gender, racial, and geographic disparities in access to computing education. Girls and underrepresented minorities (specifically African American and Hispanic students) are less likely to enroll in computer science classes in high school, including AP computer science. CS courses are less likely to be available in urban and rural schools than in those in suburban areas. However, prior to our

[3] The materials from both CS4HS workshops are available on the CE21–Maryland website, ce21maryland.umbc.edu.

survey, there was little data about the actual situation in school systems and individual schools in Maryland, and there has not previously been a strong network of teachers and administrators working together towards statewide change.

Computer science courses typically do not count towards high school graduation requirements in Maryland, are sometimes taught by teachers who are underprepared to teach the subject, and vary in content and quality across school systems and even across schools within a system. As a result, the vast majority of students leave high school without exposure to computational thinking skills, programming knowledge, or information about CS/IT career opportunities.

In Maryland there is a critical shortage of qualified computer science high school teachers Theoretically there are defined pathways to CS teacher certification in the state, but few undergraduate students or in-service teachers are pursuing these options, and the programs are not well publicized or widely available. According to the Maryland State Department of Education (MSDE), there are no undergraduate bachelor's degree programs and only two approved post-baccalaureate certificate programs in computer science in the state (at the College of Notre Dame and the University of Maryland University College); moreover, to the best of our knowledge, no new teachers have been certified by these programs in the past six years.

According to the latest Maryland Teacher Staffing Report data, from June 2009 to June 2010, only eight CS teachers were hired: six new beginning hires and two experienced new hires [8]. Only one of these was a new teacher from an in-state institution of higher education. School systems interested and able to hire CS teachers often fill this gap by hiring former industry professionals interested in teaching as a second career or by identifying highly motivated teachers in other disciplines who are interested in teaching CS despite having no substantial formal training or formal credentials.

According the Running on Empty website, Maryland has adopted only 30% of ACM and CSTA's Level II curriculum standards and 10% of the Level III standards, placing it 23rd among all states [1]. Maryland does not require students to complete a computer science course as part of its mandated high school graduation requirements. Additionally, computer science courses that are offered in individual high schools do not fulfill math or science requirements. Computer science and IT offerings are controlled at the local level and as a result, course availability, content, and the home academic department for these courses varies tremendously. Individual schools with CS/IT courses offer a combination of locally developed courses; an AP programming class; and/or classes that are part of Career and Technical Education (CTE).

The majority of high school computer science courses offered in Maryland for credit are currently situated within CTE, rather than being part of the overall academic requirements. Maryland's CTE programs fall under ten career clusters that represent the full range of career opportunities in key economic sectors of Maryland's economy. There are three computing-related programs of study (Information Technology, a Cisco IT Networking Academy, and an Oracle Database Academy). (A new program was recently proposed and approved in Computer Science but has not yet been implemented.) The IT programs include a prescribed sequence of four courses typically taken in grades 10-12, and the option to complete an internship or college-level computing course. Not all high schools offer CTE courses or programs: as a result, only 7% of Maryland high school students enrolled in the CTE IT program in 2011.[4]

Under Maryland high school graduation requirements, students are required to take one technology education ("tech-ed") course, but only a few counties offer a computer science foundational course as an option to satisfy this requirement. Moreover, these classes are typically not primarily focused on computational principles, since they must cover all of the engineering-focused technology education standards. Ultimately, the positioning of computer science courses within technology education, rather than as a stand-alone academic graduation requirement, contributes to the low number of students who study computing in Maryland.

Changing state graduation requirements and increasing the availability of CS education to all students will require a complicated, long-term change process. Our focus in this project is to gather data and evidence that can be used to provide support for systemic changes, and to build a community that can work together to create the conditions that will ultimately enable these changes.

2. NATIONAL CONTEXT

Computing professionals are an essential ingredient of our nation's future economic success [10]. The availability of a diverse, highly skilled, and well educated technology workforce is critical for meeting workforce demands and for solving the myriad of complex social, environmental, health, and security challenges of the 21st century. Progress in attracting diverse populations to each of the Science, Technology, Education and Mathematics (STEM) areas has varied by underrepresented group and by STEM discipline [9].

Unfortunately, the picture looks the bleakest for the computing disciplines just when these skills are most needed. Undergraduate enrollments in computer science have declined over the past decade: in 2010, only 2% of college-bound SAT takers reported that their intended major was computer science [11,13]. There is a significant gender gap: in 2010-11, only 12.7% of computing degrees were awarded to women. Research indicates that differences in boys' and girls' attitudes, confidence, interest, and experience with computers affect their decision whether to study computer science in college [3]. Similarly, in 2010-11, only 4.6% of computing degrees were awarded to African Americans and 6.5% to Hispanics. Differences exist by race and ethnicity in the reasons for choosing computing majors and careers. Female, African American, and Hispanic students are all more likely to cite interest in "communal" careers: those that have the power to do good and make a difference to society. In addition, encouragement matters more than ability in terms of how likely women and underrepresented minorities are to complete a computing major and pursue a career in computing. The content and characteristics of the curriculum also have a substantial effect on the retention and progression of students in STEM majors, particularly for women and other underrepresented minorities [12,14,9]. These results have implications for both the content and pedagogy of computer science education at the high school and college levels. If all high school students were exposed to computing content and careers as part of a required introductory computer science class that emphasized collaboration, affiliation, and

[4] CTE State Advisory Board Presentation:
http://www.marylandpublicschools.org/MSDE/divisions/careertech/career_technology/career_clusters/Information+Technology+Career+Cluster+Team.htm

the societal good associated with computing, then more women and underrepresented minorities might be attracted to and retained in computing majors and careers.

It is a positive development that recently (possibly in response to the economic downturn), undergraduate enrollments in CS have increased [15].. However, the gender and racial disparities persist. In order to ensure the success of all students in computer science, we must increase the quality and diversity of the pipeline by improving CS teaching standards, curriculum, teacher preparation, and availability of courses [1,4,5].

Efforts to increase the participation of diverse students in computing have been supported by the National Science Foundation's Broadening Participation Program in the past and now by the Computing Education for the 21st Century Program. Two states in particular, Georgia and Massachusetts, have made significant changes and improvements to computing education via Georgia Computes! and the Commonwealth Alliance for Information Technology Education (CAITE), respectively. Since 2006, the Georgia Computes! project has run K-12 summer camps, worked with faculty to offer and assess the impact of high-retention curricula, and used graduate students as mentors, material developers, and evaluators. CAITE, led by the University of Massachusetts, Amherst, has leveraged partnerships with community colleges in four regions of the state, as well as alliances with other STEM and information technology education initiatives, to offer programs and outreach activities for high school teachers, staff, and counselors. The dissemination of results and best practices from both of these projects is currently underway. As we begin our efforts in Maryland, we look to these projects as primary examples of the power of leveraging educational research for long-term, state-wide change. Our project is also anchored to the previous research conducted by CSTA to frame and quantify issues and challenges related to high school computer science education through the CSTA National Secondary Computer Science Survey and the Running on Empty data.

3. SURVEY OF TEACHERS

The CE21–Maryland team conducted a baseline survey of computer science teachers to collect information about their backgrounds, their professional development needs, the computing courses they teach, the students in these classes, and the specific computer science offerings in their counties. With respect to student demographics, we were particularly focused on gathering data that would help us to identify the nature and sources of possible gender, racial, and geographic disparities in the availability, depth, and quality of computing course offerings across the state.

Maryland has 24 school systems: one in each of the 23 counties and one in Baltimore City. There are 222 traditional high schools, 16 Career Technology Education (CTE) Centers, and nine CTE high schools. Because CS is not a standardized subject and does not typically have its own department, teachers in different counties and schools are often teaching out of different departments, with many different course names, and varying credentials. As a result, no statewide database of CS teachers exists.

We created an initial contact list of CS/IT teachers by reviewing the websites of the 247 Maryland high schools and following up with telephone calls, resulting in 347 contact names and emails within Maryland public high schools. This initial contact list has been incorporated into a database to which contact names are continually added.

3.1 Survey Instrument

Our survey was based largely on the CSTA National Secondary Computer Science Survey (NSCSS),[5] which consists of 38 items regarding school and student characteristics, teacher characteristics, CS/IT offerings in the school, enrollment trends in CS classes, challenges faced by the teachers in teaching CS courses, and professional development opportunities. We added 15 other items about Maryland-specific topics such as certifications, school location, curriculum, and student demographics. In addition, we expanded the response list of possible challenges that teachers face.

In May 2012, we invited the 347 teachers in our contact database to take the survey. Survey recruitment was done through multiple channels: a postcard was sent in the mail; an initial invitation was sent by email; and three email reminders were also sent, as well as a reminder email from the MSDE CTE staff to their contact list. Of the 347 invitations, six explicitly opted out (requested no further emails) or were undeliverable (the email bounced). Of the 341 remaining invitees, 26% responded to the survey (88 teachers), as did nine additional respondents from the MSDE CTE mailing. A total of 97 respondents began the survey, although 12 of these did not answer all questions, so we have data for 85 completed surveys. (Answers for partially completed surveys are included in all response statistics.)

3.2 Results and Key Findings

The survey responses yielded insights about student demographics, course offerings, teacher preparation, professional development, and the challenges perceived by these teachers. Here we present a summary of the general findings in each area, as well as some of the potentially significant relationships that are present in the data. Note that this discussion represents only some of the key findings, since the survey is too extensive to present in full detail. An anonymized summary of all survey results, along with several crosstabulated analyses, is available on our project website.

Table 1: Demographics of students taking introductory and AP computer science

		Intro CS		AP CS	
		Maryland	National	Maryland	National
Number of Students	1-10	4.3%	10%	25.0%	44%
	11-25	34.8%	24%	52.1%	36%
	26-50	28.3%	25%	12.5%	13%
	51-100	17.4%	20%	10.4%	6%
	101+	15.2%	21%	0%	2%
% Female	0%	8.7%	4%	10.4%	22%
	1-20%	60.9%	43%	77.1%	53%
	21-40%	26.1%	22%	10.4%	20%
	41-60%	4.3%	29%	2.1%	5%
	61-80%	0.0%	1.7%	0.0%	0.5%
% Minority	0%	2.2%	7%	6.3%	15%
	1-20%	52.5%	53%	66.7%	48%
	21-40%	26.1%	20%	12.5%	17%
	41-60%	10.9%	6%	8.3%	8%
	61-80%	6.3%	5%	0.0%	2%
	81-99%	0.0%	0%	6.3%	5%

[5] http://csta.acm.org/Research/sub/Projects/ResearchFiles/CSTASurvey11CSResults.pdf

Student Demographics.
Table 1 summarizes the information provided by the survey respondents about the students who take their introductory and AP-level CS classes. Participants were asked to estimate the number of students in introductory and AP CS classes, the percentage of students in these classes who are female, and the percentage of students who are members of an ethnic minority.[6] Some of the key findings about student demographics are:

- **The percentages of girls enrolled in computer sciences courses in Maryland are lower than nationally reported.** 69.6% of Maryland teachers said that the percentage of girls in their introductory CS classes was less than 20%, compared to only 47% of the teachers who responded to the national survey.
- **The percentages of minorities enrolled in introductory computer science courses in Maryland are higher than the nationally reported.** 42.3% of Maryland teachers reported that minorities made up more than 20% of their introductory CS enrollments, compared to 31% on the national CSTA survey.
- **The numbers and percentages of girls and minorities enrolled in AP computer science are even lower than in the introductory CS courses.** 87.5% of Maryland **teachers** reported that their AP CS courses had fewer than 20% girls (compared to 75% nationally); 70% said their courses had fewer than 20% minority students enrolled (compared to 63% nationally).
- **Female teachers are more likely to have higher percentages of girls in their computing courses.** Of the female teachers responding, 38.5% reported having 21% or more female students in their classes; only 16.7% of male teachers had this many students.

The dominant response for school size was 1001-2000 students (59.5% responding in this range). For a typical high school of 1500 students, therefore, the modal range of 11-25 students in introductory CS reflects only 1.2% of the student population in those classes. Even the next most frequent response of 26-50 students corresponds to only a 2.6% participation rate. Still, a significant number of schools (32.6%) do have over 50 students in introductory CS, whereas only 10.4% of schools have over 50 students in AP CS. That is, of the few students who take an introductory class, even fewer of them continue into advanced courses.

The numbers of students in introductory courses are comparable to national averages from NSCSS data, but with a stronger peak in the 11-50 range: fewer teachers in Maryland reported only 1-10 students taking introductory CS, but there were also fewer teachers who reported more than 50 students in these classes. A similar pattern holds for percentages of female students in introductory classes: the peak at 1-20% is stronger in Maryland than nationally, and there were fewer teachers in Maryland reporting high proportions (41-60%) of female students. However, this pattern is reversed for minority students: the peak at 1-20% has the same magnitude as nationally, but there are fewer teachers reporting no minority students and more teachers reporting higher percentages (21-80%) of minority

[6] The NSCSS questions regarding minority students do not specify which minority groups should be included, so these answers reflect not only underrepresented minorities but other ethnic minority groups as well.

students. This is likely because of the urban areas in Maryland, which have high percentages of minority students overall.

At the AP level, teachers report more students taking these classes overall (with a peak at 11-25 students) than nationally (peak at 1-10 students). However, the pattern is somewhat different for female and minority populations. The peak at 1-20% is higher for both of these populations in Maryland than nationally, and fewer teachers report no minority or female students in AP classes—but fewer teachers also report higher proportions of female and minority students (21-80%) than nationally.

An interesting and very apparent finding is that female teachers are significantly more likely to attract more female students. 38.5% of female teachers reported having 21% or more female students in their classes, whereas only 16.7% of male teachers had this high a proportion of female students. (Male teachers were also more likely to have no female students (11.1%) than were female teachers (2%), although this difference represents only a few teachers, so no definitive conclusions can be drawn.) Female teachers also seemed to attract more students into AP CS in general, with 32% of female teachers having 26 or more students in AP classes, and only 9.5% of male teachers reporting this level of participation. As with introductory CS, female teachers were more likely to report 21% or more of their students being female (20%) than male teachers (4.8%), and male teachers were more likely to have no female students (14.3% vs. 8.0%). Teacher gender did not seem to affect minority participation. The race of the teacher did not appear to affect female or minority participation at the introductory or AP level; however, there is too little data to draw strong conclusions. (Of the 11 African American teachers, only three responded to the questions regarding introductory classes, and only three said their school offered an AP class.)

The respondents reported their school's geographic regions as 56.5% suburban, 24.7% rural, and 18.8% urban. While we do not have geographic labels for all of the schools, examining the county-by-county response rates shows a lower rate in rural counties. The highest response rate (17 teachers, or 20% of the overall respondents) was in Montgomery County, an affluent suburban county. Only one response was provided from five counties, and no responses from four counties; all nine of these counties would be characterized as predominantly rural, most of them in the western (panhandle) part of the state and on the Eastern Shore of the Chesapeake Bay.

Course Offerings.
The next section of the survey asked about the classes offered at the respondents' schools and how many students take them. Some of the key findings in this area are:

- **Not all students have access to introductory or AP CS courses**. 61% of all respondents said that their high school offered an introductory computer science course. 56% reported that their school offered AP computer science. Rural and urban schools were less likely to report offering CS courses.
- **Some schools offer locally developed CS courses.** 43.5% of respondents reported that their high school offered other CS courses. The most commonly offered courses are web design (56%), programming (45%), computer graphics (38%), networking (38%), and keyboarding (38%).

- **The percentage of students enrolled in introductory computer science classes in Maryland high schools is alarmingly low.** The data showed that typically fewer than 50 students are enrolled in introductory computer science at respondents' schools annually. Given the typical high school size of 1,500 students, this translates to only 1.2%–2.6% of all students taking an introductory CS course in a given year (a comparable percentage to that reported in the national CSTA 2011 survey results).
- **85% of teachers said that there were students at their high school who are not currently enrolled in CS, but who should enroll in CS courses.** The three most common reasons teachers gave for students not taking CS are a lack of understanding of its importance, insufficient time in students' schedules, and the lower importance given to elective classes.
- **Respondents attributed the lack of CS offerings at their schools to a number of causes:** CS is not a graduation requirement (63%); budget restrictions (52%); CS is not a priority of their school system (50%) or school (43%); insufficient student interest (46%).

Nearly a tenth of the respondents (9.4%, or eight teachers) reported that their school offers no CS/IT courses. The most common reported reasons for a lack of CS/IT courses include insufficient student interest (five responses) and budget restrictions (five responses). All but one of these teachers felt that their school should offer CS courses.
Fewer than two-thirds of the schools offer an introductory computer science course (61.2%), and just over half offer AP courses (56.5%). A keyboarding class is offered in 37.6% of the schools; 24.7% offer an Oracle or Cisco Academy (four-course CTE "completer" sequences that lead to Oracle or Cisco certification); and 43.5% offer "other CS/IT courses" (see Figure 1 for response statistics on different courses offered).

We generated a Wordle[7] visualization using the responses to two open-ended questions on the survey, which asked teachers to provide the title and describe the content of the introductory CS course at their school. The visualization illustrates that these courses are primarily focused on programming rather than introducing students to the breadth of the fields of CS and IT. It appears that Java is the primary language being taught in these courses, and that Java itself is a primary focus of the content. The Wordle provides some evidence that introductory CS courses may not be emphasizing the breadth of computer science, computational thinking, career opportunities, or the importance of CS for solving societal problems—which have all been shown to be important topics for engaging students and increasing their interest in computing. These latter topics form the basis of the AP CS Principles course that is currently under development by The College Board and the CS education community.

The geographic disparities are quite striking. Specifically, CS offerings are less available in rural and urban schools than in suburban ones, although the pattern of offerings is different in rural and urban schools. 28.6% of rural schools offered no CS/IT courses; this was the case for only 6.3% of urban schools and only 2.1% of suburban schools. Introductory CS courses were offered by 68.8% of suburban schools, but by only 50.0% and 52.4% of urban and rural schools, respectively. AP offerings are distributed similarly to introductory

[7] A wordle is a visualization used to emphasize more frequent words in a document or collection by showing them in a larger font than less frequent words. See http://www.wordle.net.

offerings: AP CS is offered by 62.5% of suburban schools, 43.8% of urban schools, and 52.4% of rural schools.

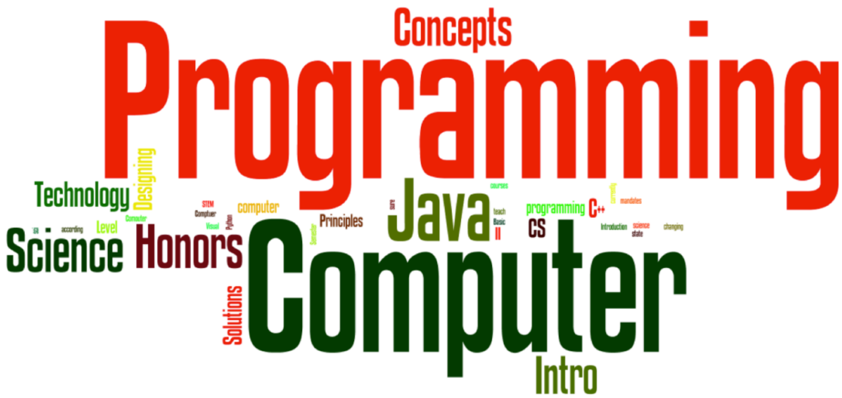

Figure 1. Wordle of the titles and brief description of introductory CS courses from the teacher survey.

The numbers of students, particularly in AP courses, also vary between geographic regions: in urban schools that do offer AP CS, most respondents indicate that only 1-10 students take the class each year. In suburban schools, the most common answer was 11-25 students, but some reported that there were 26-50 or even 51-100 students in AP CS.[8] In the rural schools with AP CS, most (70%) reported 11-25 students in the classes.

21.2% of the respondents' schools overall offer the Cisco Academy, but almost none of these are in rural areas (only 4.8% of rural schools offer the Cisco academy, compared to 27.1% of suburban schools and 25.0% of urban schools). Similarly, 43.5% of schools overall offer other CS/IT courses, with these offerings being far more common in suburban schools (56.3%) than rural schools (only 14.3%).

Teacher Preparation and Professional Development.
A key finding about the teachers and their educational backgrounds is:

- **Fewer than half of all CS teachers are certified in CS, with a significant certification gap between suburban and rural/urban schools.** Only 40% of respondents were certified in CS; 31% were certified in Business Technology and 27% in Mathematics. CS teachers in suburban schools were more likely to be certified in CS.

The geographic disparities are again reflected in teacher certifications. Of the suburban teachers, 55.3% are certified to teach computer science, but only 25.0% of urban and 19.0% of urban teachers hold a CS certification. The most common certification in the latter schools is business education (43.8% of urban teachers and 38.1% of rural teachers).

[8] These are likely to be teachers from magnet schools that have unusually large CS programs; to maintain anonymity, school names were not requested, but these responses are all from the two most affluent counties in Maryland, Howard and Montgomery.

Technology education was also a common certification across all regions (43.8% of urban teachers, 46.8% of suburban teachers, and 33.3% of rural teachers). Mathematics was quite common in suburban schools (34.0%), but was seen less frequently in urban (18.8%) and rural (19.0%) schools.

Interestingly, teachers in both suburban and rural schools had more years of experience, with the dominant response for those regions being 15+ years (47.9% of suburban teachers and 52.4% of rural). Urban teachers were fairly evenly distributed across the experience ranges, but the slightly dominant response was 4-7 years (37.5%). Experience seems to matter for diversity: of the 13 teachers reporting more than 20% female students in introductory CS, for example, all but two had eight or more years of experience. Similarly, of the 20 teachers reporting more than 20% minority students in these classes, all but one had eight or more years of experience. This pattern continues to the AP level: all but one (i.e, 88%) of the eight teachers with fewer than eight years of experience had 1-20% female and 1-20% minority students in their AP classes; of the 38 more experienced teachers, 11 teachers (29%) had 21% or more minority students. (It is not possible from this data to tell whether there is causality in either direction: i.e., whether more experienced CS teachers attract more students, or whether schools with more CS students are able to hire more experienced teachers.)

Reflective of the demographics in Maryland, African American teachers were more common in urban schools (25.0%) than in suburban (12.8%) or rural (4.8%) schools. Most teachers in all areas were Caucasian, with a few Asian American teachers and no Hispanic or Native American respondents. About half of the teachers were female, although suburban teachers were more likely to be male (61.7%) than were urban (43.8%) or rural (42.9%) teachers.

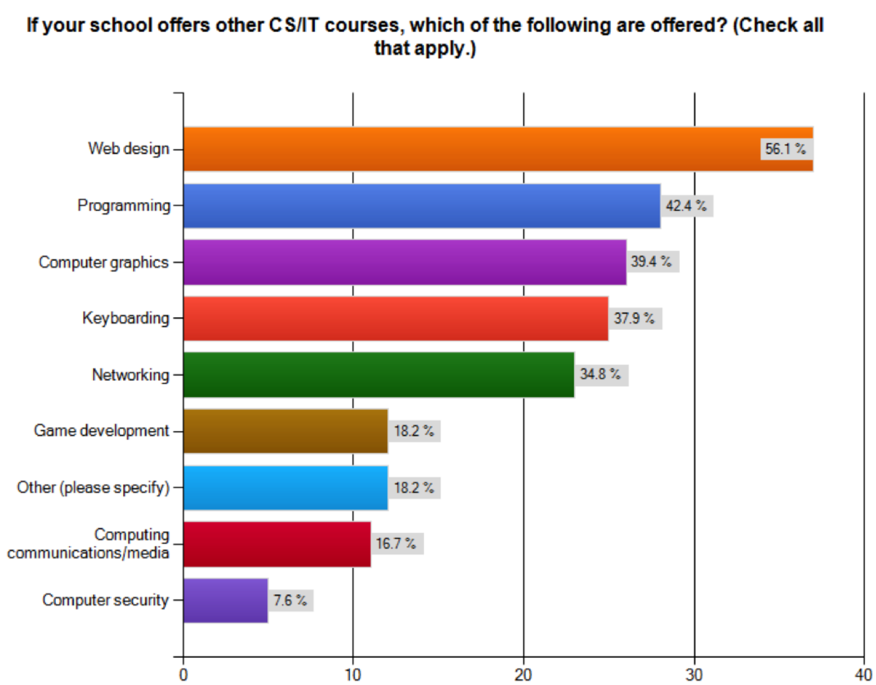

Figure 22. Survey responses about course options.

Challenges Perceived by Teachers.

Some of the key findings about the challenges teachers face are:

- **More than 75% of the respondents reported a lack of student subject knowledge, lack of student interest and enrollment, lack of staff support and interest in CS, and rapidly changing technology as challenges.** Differences by type of school setting were observed. A lack of student subject knowledge was the number one reported challenge across teachers in suburban, rural, and urban schools. Higher percentages of teachers in urban and rural schools reported challenges in the other three areas. A notable finding was that many teachers in suburban schools reported the additional challenge of simultaneously teaching more than one subject in the same classroom.
- **75% or more of respondents reported a lack of parental encouragement to take CS, lack of guidance staff support, insufficient student math preparation, and the inability to attract women and minorities to CS courses as additional challenges.**
- **Over 80% of teachers indicated a need for convenient, low-cost professional development opportunities** offered throughout the school year and in late June after school ends. They reported a preference for workshops, college courses, and networking opportunities. Because of budget constraints, obtaining approval to have a substitute teacher for professional development activities is also a challenge.
- **Half of the respondents had not heard of the CSTA model CS Curriculum.**

Teachers reported experiencing a wide range of challenges in teaching CS classes. Again, in this area, there were some geographic differences. Rapidly changing technology was cited as a major challenge in 42.9% of urban schools and 52.9% of rural schools, but in only 23.9% of suburban schools. Similarly, lack of support by the staff was perceived as a major challenge by the plurality of urban (42.9%) and rural (50.0%) teachers but only as a moderate challenge by suburban teachers (41.3%). The same pattern was seen for "lack of curriculum resources," "lack of hardware/software resources," "lack of teacher subject knowledge," and "lack of professional development opportunities," among others.

"Difficult subject matter" was seen as less of an issue, but was still reported more frequently as a moderate challenge in urban (69.2%) and rural (52.9%) schools than in suburban (39.1%) schools. Interestingly, though, the related problem of "lack of student subject knowledge" was uniform across all school types, seen as a moderate challenge by urban (57.1%), rural (52.9%), and suburban (55.6%) teachers about equally.

The single challenge that was perceived as more of a concern by suburban teachers (with 43.5% reporting this as a major challenge) than urban (21.4%) or rural (31.3%) teachers was "being asked to teach multiple CS related courses in the same classroom at the same time." Presumably this disparity can be explained in part by the fact that multiple CS classes simply are not available at many of the rural and urban schools.

4. COMMUNITY BUILDING

The CE21–Maryland community building efforts to date have focused in three major areas: professional development opportunities for high school teachers, the establishment of a local chapter of CSTA, and a mini-summit for teachers, administrators, college faculty, and industry representatives.

4.1 Professional Development for Teachers

Our first outreach effort to high school teachers was a Google-sponsored CS4HS professional development workshop at UMBC in July 2011.[9] Twelve teachers attended; the event included sessions on Computing Education for the 21st Century, First Lego League robotics, Finch robots, NetLogo, Scratch programming, strategies for increasing diversity, and game programming. For several of the teachers, this workshop was the first opportunity they had had to meet and interact with other local CS teachers, and the event created a great deal of energy and zeal for improving CS education. The feedback that we received from the participants on our post-event survey was very positive: 88.9% rated the event overall as Excellent and 11.1% as Good. 90% of the teachers strongly agreed that they gained new ideas they can use in their CS classes, that they felt more connected to other high school CS teachers in the state, that their students would benefit from their experience, that they found the workshop to be worthwhile, and that attending CS4HS had enhanced their professional development.

Following the success of the first workshop, we offered a second CS4HS workshop in August 2012.[10] Twenty teachers attended this event, including two middle school teachers. The structure was similar to the first year, keeping some of the same sessions and adding sessions on the AP Computer Science Principles curriculum, cybersecurity, and AppInventor mobile app development. As with the first CS4HS, the response was overwhelmingly positive. All of the teachers gave rating of 4 or 5 (out of 5) to the overall workshop quality, the degree to which they expect to incorporate knowledge learned into their classroom activities, whether they gained new ideas, and whether their students will benefit; 90% of the teachers gave a rating of 4 or 5 to questions about whether they had built connections with other teachers and whether they felt an increased sense of community.

4.2 CSTA–Maryland Local Chapter

At the end of the CS4HS workshop, we established a Maryland CSTA chapter,[11] with officers elected from among the workshop attendees, and the initial members being the 12 teachers and several UMBC representatives. The 2011 CS4HS participants were very interested in further professional development, so we worked with the CSTA-Maryland leadership to organize a NetLogo workshop at UMBC in October 2011, which eight teachers attended. The chapter has grown significantly over the ensuing year (Figure 2). The graph shows that each organized activity brought new members to the chapter: after the initial chapter members joined, ten teachers who were at or heard about the October 2011 workshop subsequently joined; the advertising for our August 2012 workshop brought a noticeable increase in membership in June and July 2012.

[9] http://maple.cs.umbc.edu/cs4hs/schedule2011.html
[10] http://maple.cs.umbc.edu/cs4hs/schedule.html
[11] Chapter website: https://sites.google.com/site/cstamaryland/home

The CSTA-Maryland chapter meeting that was held on the morning of the third day of the August CS4HS workshop was very lively: most of the 20 CS4HS participants attended, along with a number of teachers who had heard about the chapter or the mini-summit that was being held that day. New board members were elected; several new positions (including industry liaison, middle school representative, and government liaison) were created; and a number of new initiatives (including another UMBC-hosted professional development workshop scheduled for October 2012) were proposed. Following the 2012 CS4HS workshop and mini-summit, membership nearly doubled over a period of just a few weeks.

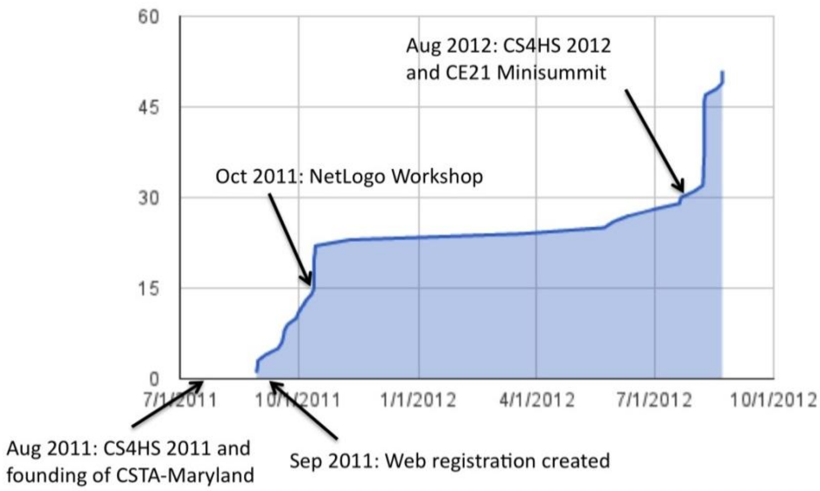

Figure 3: CSTA Membership Growth

4.3 CE21–Maryland Mini-summit

The final session of the 2012 CS4HS workshop overlapped with an all-day mini-summit[12] that brought 50 high school teachers, college faculty, administrators, and industry representatives together to discuss the state of CS education in Maryland. To take advantage of the overlap, we organized a panel of some of the teachers who had participated in CS4HS to share their experiences, and created an engaging video highlighting the teachers' thoughts and observations. (This video is available on our website.) The mini-summit also included a keynote talk by Dr. Jan Cuny about NSF's diversity- and CS education-focused programs, a presentation of the national context of computing education, a presentation of our initial survey results, and an interactive session on future directions and how the community could work to improve CS education in the state. Comments from the sessions revealed the following themes:

- If introductory CS courses could be used to satisfy the mandatory technology education credit, they would attract more students, especially those groups who are currently less likely to try CS. Montgomery County and Charles County have successfully adopted this approach.

[12] Minisummit website: http://ce21maryland.umbc.edu/ce21-maryland-mini-summit

- Parents, students, and guidance counselors need to be educated that CS is much more than programming: it is about problem solving, has broad implications for improving lives, and is an integral part of our everyday lives.
- Principals and superintendents must be educated and made aware of the importance of CS for their students and for our local and state economies.
- Many schools and teachers need more resources and support to effectively offer and teach CS courses.
- CS can be made more relevant to students by "marketing" CS to students using fun, engaging media and activities such as video announcements, demonstrations, field trips, and the use of phone apps.
- Current interest by the general public in cyber security is being leveraged to promote CS to parents and students along with participation in regional and national cyber competitions. Parents are being educated about CS at various school events such as the display and demonstration of student projects.

Mini-summit attendees were asked to complete a brief online evaluation after the event. A total of 21 attendees responded to the survey invitation. Those who responded reported gains in knowledge about the current state of CS education in Maryland, increased awareness and knowledge of national computer science initiatives, and interest in learning more about CS in their own school district.   Attendees also reported gains in their level of commitment to increasing student interest in CS and contributing to the long-term change of CS education in Maryland. The following responses illustrate the most important things that attendees reported learning at the summit:

- "Understanding the wide variance in the way that CS is implemented around the state–I can see that this is one of the major problems that we have."
- "That I am NOT alone-that there are many other geographical areas suffering from the same [CS] issues.
- "Resources to increase interest of students and parents in computer science education."
- "The stats on minorities and women."

Attendees were also asked what they plan to do with the information they gathered at the mini-summit. The following responses illustrate the activities that attendees from various constituency groups plan to pursue:

- "Share with colleagues, implement some of the tools gained from the sessions, relay information about the upcoming AP computer science course, continue to explain the crisis of computer science to ALL interest individuals." –High school teacher.
- "Try to develop more ways the private sector can get involved in improving CS education." –Industry professional.
- "I am going to work with MSDE to update the CTE computer science program of study." –K-12 administrator.
- "Work with other schools so that we can support each other and reach a level that is better for computer science education in the state as a whole." –Faculty member.

5. CONCLUSIONS AND NEXT STEPS

Our teacher survey provides the community with a broader and deeper understanding of the current situation and challenges surrounding CS education in Maryland. The community building activities that we have led over the past year have created a strong, active, and vocal community of educators and administrators who are committed to our shared mission of providing high-quality computing education to all students in the state of Maryland.

Our experiences and the data we have collected inform the following four recommendations for improving high school computer science education in Maryland.

1. Continue to grow the computer science education network in Maryland.
2. Educate the broader community about the CS education crisis.
3. Increase the availability of high-quality CS courses for all Maryland high school students.
4. Provide effective professional development opportunities and develop certification programs to expand the number of highly qualified high school CS teachers.

1. Continue to grow the computer science education network in Maryland. Before the CE21–Maryland project began, there was not a visible community of computer science teachers in Maryland. The project has created and maintains a contact database of over 400 CS teachers, K-12 administrators, and other professionals who have attended our events or who are points of contact at particular schools or institutions. A CSTA–Maryland chapter has been formed and continues to grow. This network needs to be expanded to include superintendents and principals as well as other MSDE administrators, since they are the key decision makers in local schools and state systems. More industry professionals also need to be included on the project advisory board and at the summit in May 2013. Corporations in Maryland have a major stake in solving the shortage of computing professionals and many are actively participating in STEM education efforts.

2. Educate the broader community about the CS education crisis. The documents and data generated by CE21–Maryland should be actively shared with teachers, administrators, faculty, industry professionals and legislators. Information about the CS crisis must also be shared with local and state legislators and collaboration with STEM councils around the state must be pursued in order to achieve long-term change.

3. Increase the availability of high-quality CS courses for all Maryland high school students. The survey data reveal disparities in the availability and content of introductory CS and AP CS courses across high schools in Maryland. The data and discussion from the mini-summit confirmed that girls and minorities are not proportionally participating in CS courses. The decreased availability of CS courses in urban and rural schools is problematic. In addition, we have had difficulty collecting data from or involving teachers from the western and eastern parts of the state in our survey and project activities. Current budget constraints and the small likelihood of changing high school graduation requirements in the short run demand that pragmatic solutions be identified within individual schools and within school districts. One promising approach already adopted by a number of school systems is to develop introductory CS courses that the technology education state graduation requirement.

4. Provide effective professional development opportunities and develop certification programs to expand the number of highly qualified high school CS teachers. Participation in our CS4HS workshops has grown and we have gathered useful information about computer science teachers' professional development needs. Since its formation, the CSTA–Maryland chapter has offered two one-day professional development workshops at UMBC and a third is planned for Spring 2013. CSTA–Maryland and the national CSTA organization are key collaborators for developing and implementing ongoing professional development sessions for computer science teachers. In addition, the CE21–Maryland team should continue identifying additional funding to develop more in-depth computer science teacher training and curriculum development (particularly focusing on the new AP CS Principles effort) and to develop pathways to certification, such as a combined B.S. / M.A.T. program leading to certification in computer science education.

Our next focus areas are ensuring continued growth of CSTA–Maryland, creating a secondary CS teacher certification program at UMBC, performing further data analysis, and preparing for a larger summit meeting to be held in Spring 2013. The summit will bring up to 150 high teachers and administrators, college faculty from community colleges and universities, MSDE representatives, high school students, and industry representatives

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