# Benefits of Exposing K-12 Students to Computer Science through Summer Camp Programs

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***Abstract*—In this paper we provide an overview of the CS@SC Summer Camps, which is a week-long exposure program to teach K-12 students about computer science. Students attend the program on campus at the University of Southern California, experiencing life as a college student while learning about a valuable field that is currently in high demand. The camps have a proven record of drawing interest from groups that are under-represented in computer science: girls (over 40% attended), minorities (over 70% attended), and low income families (over 80% of attendees with an annual family income less than $40k). Although a majority of the attendees expressed interest in science, technology, engineering, and mathematics (STEM) fields prior to attending camp, the camps further increased interest by over 12%. We conclude that exposure programs such as CS@SC serve an important purpose, that of increasing the diversity and number of students pursuing education and careers in STEM fields. (***Abstract***)**

***Keywords—STEM, CS, early exposure, diversity initiatives (*key words*)***

## I. Introduction

There is no doubt that computer science is currently a popular discussion topic for educators. The New York Times ran an article detailing "coding" being added to the traditional educational areas in schools around the country ("Reading, Writing, Arithmetic, and Lately, Coding" [1]), while The Washington Post had a similar blog post, about students of today needing a fourth R ("reading, 'riting, 'rithmetic, and 'rithms" [2]). Regardless of the vocabulary used in popular press, competing in an increasingly technological future is sure to require basic knowledge of computer science, specifically, computational thinking. Michael Resnick, a professor of learning research at the MIT Media Lab, said, "Coding is the new literacy. To thrive in tomorrow's society, young people must learn to design, create and express themselves with digital technologies" [3]. In fact, President Barack Obama even made computer science a priority in the State of the Union Address in 2016, saying, "But tonight, I want to go easy on the traditional list of proposals for the year ahead. Don't worry, I've got plenty, from helping students learn to write computer code to personalizing medical treatments for patients" [4]. He continued to say, "In the coming years, we should build on that progress by providing Pre-K for all and offering every student the hands-on computer science and math classes that make them job-ready on day one" [4]. All the hype surrounding "computer science for all" education does not come without a number of challenging questions, such as these:

- should computer science be included in the normal K-12 curriculum?
- if so, what subject(s) get removed or reduced?
- how do we encourage students to become interested in computer science?
- as the demand for computer science increases, will we be able to diversify equally across gender, ethnicity, and family income?
- will academic institutions be able to keep up with the rising enrollments as demand increases?

There are many other questions that arise when considering the skyrocketing demand of computer science. For example, the United States Bureau of Labor claims that there will be a shortage of about 1 million qualified computer scientists in 2020 [5]. One way to try to increase enrollment in university-level computer science programs is to provide students with early exposure to the field, in a manner that will generate interest. There are many models that provide students with such exposure or ongoing education in the field, including traditional curriculum in K-12 or post-high school institutions, coding boot camps, after-school programs, continuous engagement programs, and summer camps, among others. In this paper, we will provide a study of one-week free and low cost summer camp programs, that expose K-12 students to computer science through coding. Although the exposure is limited to one week, students benefit through:

- an increased interest in computer science and science, technology, engineering, and mathematics (STEM),
- an opportunity to learn about computer science via hands-on assignments they can relate to,
- an experience with diverse peers that varies from the current trends in industry,
- the excitement of realizing that computer science is a challenging field but that it is not impossible,
- relating to mentors with similar backgrounds or experiences

Section II of this paper offers an overview of existing summer camp and other exposure programs and how they help support diversity and encourage increased participation in computer science. Section III discusses the specifics of the CS@SC Summer Camps (http://summercamps.usc.edu), which is a program organized by the authors of this paper at

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USC. Section IV gives the beneficial results of the CS@SC Summer Camps related to interest in STEM and diversity, and Section V provides conclusions and future work.

## II. Related Work

There are many programs that exist to expose or educate students in computer science, specifically:

- post-high school formal education (i.e. community colleges and universities)
- K-12 formal education
- after-school and weekend exposure programs (both for-profit and non-profit)
- after-school and weekend retention programs (both for-profit and non-profit)
- coding bootcamps
- summer camp exposure programs (both for-profit and non-profit)

As other research has shown, girls and minorities lose interest in STEM fields in middle school, which is primarily when students start associating with stereotypes that they have heard from their peers [6]. K-12 education and outreach activities provide means of encouraging diversity by getting students involved and interested in computer science before they begin associating with stereotypes, thereby losing interest and exposure to lucrative STEM fields.

USC is certainly not the first university to offer summer camps that teach computer science. Starting in the early 2000s several universities began to offer CS focused summer camps [13-16]. Specifically designed to combat gender-based stereotypes and to address the under enrollment of female students in computer science, the students at these camps were middle or high school girls only. The camps were an attempt to improve the students' views of CS as a possible career field and to increase the number of female college level CS majors, specifically during the decline in CS enrollment following the "dot-com bust". Similar camps have continued into the 2010s with the goal of inspiring more female CS majors, now that CS enrollments are surging again [17]. CS@SC has a similar goal, however we are focused on increasing interest in CS in particular and STEM in general, among students of both genders that are of diverse economic and social backgrounds.

Using summer camps to improve computing education enrollment has also been a focus of some efforts. The GaComputes [18] project, a multi-year, statewide effort from 2006-2012, developed summer camps at 11 colleges and universities across the state of Georgia. The goal of the project was to broaden participation in computing, especially to engage under-represented groups.

Summer camps are also seen as a recruiting opportunity for the host university through exposure to "college life" for middle and high-school students. [19-20].

University-hosted CS summer camps expose students to a variety of computing-related areas and applications; the most popular can be broadly categorized as follows: games [16,21], mobile app development [22-25], and robotics [19,26]. Outside these categories, camps featuring cyber security [27] and 3D printing [28] also exist.

By way of teaching innovation, CS@SC uses Scratch Jr. [7] and Scratch [8] for younger students, which naturally leads to a focus on developing games, stemming from the graphical nature of the programming platforms. We are pleased to notice that the visual drag-and-drop, code-free nature of Scratch and ScratchJr seems to be quite appealing to students, who find the colorful, easy-to-use, expressive interfaces to be inviting and non-threatening. In contrast, a 'traditional' language such as Python or Java, when taught to students with zero prior experience, tends to be rather discouraging and frustrating on account of their precise syntax requirements; we find this to be especially true for younger students. We find that the text-based syntax gets in the way of our main goal, which is to impart computational thinking. Note that we are not the only summer camp to choose Scratch [29-30]. The next version of Scratch will include a way to connect with the popular Arduino microcontroller board, and an extension mechanism that would help us author more capabilities (such as visualization modules for physics and biology simulations). This pair of additions to Scratch will help us incorporate more STEM-related topics and projects into our curriculum, which would hopefully lead to even more student interest in STEM. Our older students also use Java and Python to develop various projects, (including ones other than games) because they have the patience required to learn a text based language. Detailed studies have been presented that show the effectiveness of summer camps in increasing CS and STEM interest among campers [31], and workshops are hosted at conferences to help organizers effectively plan and execute quality CS summer camps [32-33].

## III. CS@SC Summer Camps Overview

Founded jointly by the Viterbi School of Engineering at USC and the Institute for Education (IFE), the CS@SC Summer Camps provides free and low cost computer science exposure to K-12 students in a university environment. To coincide with the typical K-12 academic day, the camps run daily from 8:00a.m. to 3:00p.m. for one week at a time. Multiple camps for different age ranges are run simultaneously, with the following topics taught for the specified grade levels:

- Scratch Jr. [7] for Kindergarten-2$^{nd}$ grade students
- Scratch [8] for 3$^{rd}$-8$^{th}$ grade students
- Java or Python for 7$^{th}$-12$^{th}$ grade students

There are multiple levels of each camp, enabling students to attend a camp based on their own experience level or to allow students to attend multiple weeks if desired. The curriculum has been custom-developed by the authors of this paper in collaboration with USC Rossier School of Education faculty and K-12 teachers.

The camps are hosted on campus at USC in order to provide students with a college experience. They are taught by USC undergraduate and graduate computer science students, and they are exposed to college life through changing classrooms, eating in the dormitory cafeteria, and being immersed in the natural environment of college students. The teaching assistants (TAs) also act as mentors to the students, eating lunch with them, interacting with them throughout the day, and hopefully relating to them in a manner that encourages the students to realize that they are capable of pursuing a STEM field just like the TAs.

### A. Schedule

All of the students begin the day together in a large auditorium where they work together to solve a thought-provoking question to help them realize that computer science involves critical thinking skills.

The students are then broken into the individual camps that consist of up to 20 students. The camps maintain no more than a 1:10 ratio of teachers-to-students. The students then walk through campus with their teachers to their classrooms.

There are two 15-minute breaks during the day – one in the morning and one in the afternoon. There is also lunch in the middle of the day at a dormitory or other on campus cafeteria (which is typically one of the highlights of the camp for many students).

### B. Instruction Method

The curriculum is based on scaffolding to ensure that students acquire specific skills before moving onto more advanced ones. Since the camps are focused on teaching students how to program, there is a three-step model that is followed:

1. Students are taught a topic by the TAs and shown a small example demonstrating the topic.
2. The TAs create a program with the students that use the newly-learned topic. The program is displayed on a projector so students can copy it if they wish to.
3. The students are given a description of a different program that reinforces the topic and are tasked with creating the program on their own. The TAs are available to help students if there are questions.

Some of the programs that fall under the third step build on each other so the students are able to create an application with more features. Some of the example programs for that are as follows:

- Storyboarding (Beginning Scratch Jr.)
- Catching Falling Fruit (Intermediate Scratch Jr.)
- Pac-Man (Beginning Scratch)
- Flappy Bird (Intermediate Scratch)
- Hangman (Java, Python), with additional features being added on during subsequent levels of the camp

In addition, all of the students are provided with USB drives so they can save all of the programs and use them at home.

### C. Advertising

Because of the free and low cost nature of the camps, advertising has not been a major concern. During the first year, the camps were advertised through fliers and emails to 15 elementary, middle, and high schools that surround USC's main campus in downtown Los Angeles and USC's health sciences campus in east Los Angeles (known as the USC Family of Schools [9]). A web site was also developed (http://summercamps.usc.edu) that allowed parents to add an email address to a mailing list. Although there was only space for around 200 students to attend during that first summer, there were over 600 applicants.

In subsequent years, advertising was only done through having a website and emailing the constantly-expanding mailing list, which has now grown to over 2,000 addresses. In 2017, there were over 1,200 students who applied to attend nearly 3,000 camps (i.e. each student applied to attend an average of 2.5 camps).

### D. Funding

The number of students who are able to attend the camps each summer is typically limited by two factors – space and funding. The amount of space available at a university is a hard problem to solve that typically needs institutional support from upper administration. If the administration is supportive of the activity requesting the space and can prioritize it, space is easier to reserve. However, regardless of the priority of the activity, there is still a limit to the amount of space available without constructing new buildings (which is a very expensive venture) or renting space off campus (which does not provide the same experience for the students). For the purposes of this paper, let's assume that there is space available on campus, which is the case for the CS@SC Summer Camps.

The issue of funding is a more tractable problem that is within the control of the organizers of the program. With the need for computer scientists continuing to grow [5], many organizations are happy to support efforts to increase enrollments and interest in the field. The Institute for Education (IFE), a nonprofit based in Washington DC, understands this problem and partnered with the Viterbi School of Engineering at USC to create the CS@SC Summer Camps in 2015. Through the joint efforts of the authors of this paper and IFE, additional organizations have funded students to attend the program free of charge. Individuals, specifically parents of some of the students who have attended the camps, have also generously provided donations to allow other students to attend.

As the program continued to grow and expand, local school districts saw the benefit in sending their students to the camps. Title I funding has been used to allow students from low income schools to attend the camps, and funding from technology education accounts has helped as well. In 2017, nearly 400 of the students who attended the camps were from school districts who supported students to attend free of charge.

## IV. Results of Camps

Although the massive response of parents who are interested in their children being exposed to computer science is impressive, there are many other interesting statistics abou t the demographics of the attendees. For example, the percentage of girls related to boys is shown in Fig. 1, with the number of girls attending each year being over 40%, with the first year being 60% (though this is due to an all-girls camp that was offered the first year, skewing the numbers from subsequent years). The national average of female students graduating with Bachelors' degrees in computer science is currently 18% [10], providing more than double that percentage being exposed in the camps. To support this even further, USC's Viterbi School of Engineering boasts an incredible 44% of incoming freshman students in the 2017-2018 academic year are women [11].

The percentage of students attending the camps broken down by ethnicity is provided in Fig. 2. Most likely due to the demographics of the neighborhoods surrounding the USC campus, minority ethnicities (Hispanic, African American and Other from the figure) account for between 70-80% of the attendees each year. With the national average Hispanic college graduation rate in STEM being approximately 11% and the African American college graduation rate in STEM being 9% [12], the camps have more than seven times as many minority students attending the camps than graduating college with STEM degrees. With more programs providing similar exposure to minority students, we can hopefully try to bridge the gap between the percentage of the minority population and the percentage of minority students graduating college with STEM degrees.

Although the number of girls and minorities attending the camps far exceeds the national average of those demographics graduating from college with STEM degrees, the impact the camps have on these students is also an important consideration. The students were surveyed at the beginning of the camp and at the end of the camp to find out how interested they were in STEM fields. Specifically, students were asked, "What is your interest in Science, Technology, Engineering, and Mathematics (STEM)?" Students answered the question on a scale from 1 to 5, with 1 being "no interest" and 5 being "extremely interested". Fig. 3 shows the average of the students each year based on how they answered at the beginning of the week and at the end of the week. It is important to note that students who attend this camp typically had at least a slight interest in STEM, but the result for all three years combined increased from 3.99 before the camp started to 4.46 at the end of the camp. Over a mere 35 hours of exposure to computer science, students experienced an average of nearly a 12% increase in their interest in STEM, with many students stating over a 50% increase (i.e. increasing interest by more than 2 full points).

Fig. 4 depicts the percentage of students interested in STEM fields before and after the camp, aggregating all three years of the camps together. As can be seen, there was already a strong interest in STEM before the camp, with 69% of the students expressing a strong interest (4 or 5), but 83% of the students expressed a strong interest after the camp, with an increase of 15% of the students stating "extremely interested".

## V. Conclusions and Future Work

This paper describes the CS@SC Summer Camps, which is an exposure program in computer science for K-12 students. Through corporate and individual donations, many students attend the camps for free or low cost, and the benefits include an increase in participants' diversity (gender, ethnicity, and low income), foundational education in computer science (emphasizing computational thinking), and a broader interest in STEM fields.

The camps have experienced more than double the percentage of girls attending than the national average for graduation rates in STEM, nearly seven times the percentage of minorities attending compared to the national average for minority graduation rates in STEM, an increase in the interest students have in STEM fields, as measured before and after the camp, and over 80% of the attendees with an annual family income of less than $40k

Although the benefits of the camps include breaking down the gender, ethnicity, and income boundaries to computer science, more work still needs to be done. The CS@SC Summer Camps model is completely open source and scalable to as many students as can be handled based on classroom space and funding. Replicating the model at different universities is a major goal of the camps since students should not be limited to this exposure based on their geographical proximity to USC. The CS@SC Summer Camps is committed to working towards equality among gender, ethnicity, and income in computer science.

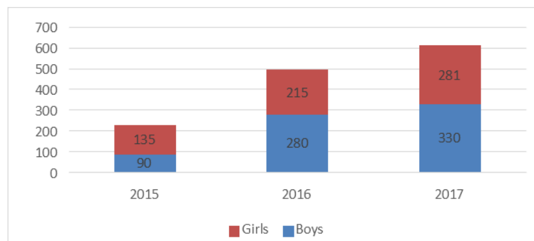


Fig. 1. Number and Percentage of Students Attending by Gender

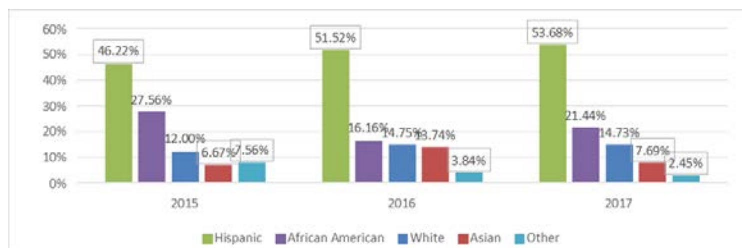


Fig. 2. Percentage of Students Attending by Ethnicity

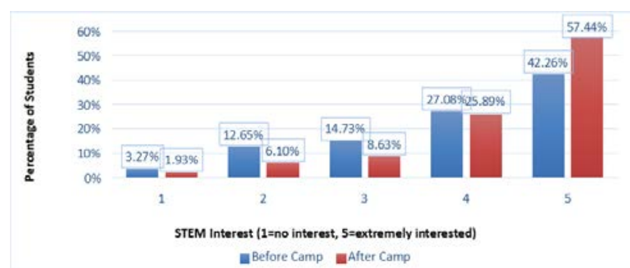


Fig. 3. Student Interest in STEM as Surveyed Before and After the Camp (scale from 1 to 5)

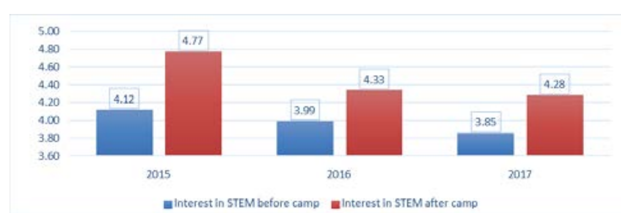


Fig. 4. Percentage of Student Interest in STEM as Surveyed Before and After the Camp

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