Promoting Underrepresented Minority Students' Interest in Computer Science: Motivation and Sustained Interest

Jung Won Hur
Auburn University
United States
jwhur@auburn.edu

Jay Bhuyan
Fan Wu
Cassandra Thomas
Li Jiang
Tuskegee University
United States
jbhuyan@tuskegee.edu
fwu@tuskegee.edu
cthomas@tuskegee.edu
ljiang@tuskegee.edu

Chih-hsuan Wang
Auburn University
United States
wangchi@auburn.edu

Kai Koong
Tuskegee University
United States
kkoong@tuskegee.edu

To promote the interest in computer science (CS) among minority high school students from low-income families, a one-month Summer Academy was offered, followed by a semester-long online mobile app development project. The study aimed to investigate participants' motivation for applying to the program, the impact of the program, and factors influencing their persistence in CS activities. The analysis of 31 participants' surveys and interview data revealed that family encouragement and early exposure to CS played a significant role in motivating participants to apply to the program. Among the students who continued to participate in the mobile app development project, a higher level of STEM identity and strong self-determination were observed, which positively impacted their persistence in CS activities. The study provides evidence that offering CS learning opportunities to minority students is crucial in promoting their interest and persistence in CS activities.

Keywords: Computer Science, Minority Students, Diversity Gaps, Persistence, Motivation

Introduction

Although the number of female and minority students (e.g., Black/African American, Hispanic/Latinx) earning degrees in science, technology, engineering, and mathematics (STEM) has increased since 2000, significant ethnic and gender disparities remain (Niepel, Stadler, & Greiff, 2019). According to a Pew Research report (2021), Hispanic and Black workers are underrepresented in the STEM workforce, comprising only 8% and 9% of STEM workers respectively, compared to 17% and 11% of total employment across all occupations. Despite the increasing number of female students earning college degrees, certain fields such as engineering, mathematics, and computer

science remain predominantly male (Jelks & Crain, 2020). Educating qualified workers in computing is critical as the demand for computing-related jobs continues to grow, with over 410,000 software developers and quality assurance analysts needed in the U.S. from 2021 to 2031, according to the Bureau of Labor Statistics (2022). As most industries rely on technology to enhance efficiency, the demand for individuals with a deeper understanding of computer science (CS) is expected to continue increasing (Wurman & Donovan, 2020).

To address this demand, governments, schools, and non-private organizations have collectively worked to promote CS education in K-12 schools (Margolis & Goode, 2016). The percentage of high schools in U.S. offering at least one CS course has grown from 35% in 2018 to 53% in 2022 (Code.org, CSTA, & ECEP Alliance, 2022). However, disparities in CS course access still exist, with schools in rural areas and schools with high percentages of low-income or Black and Hispanic students being less likely to offer CS courses. To address this issue, we developed a one-month Summer Academy focusing on mobile app development. The purpose of this study was threefold: (a) to investigate students' motivation for applying for the program, (b) to assess the program's impact, and (c) to investigate the factors affecting students' STEM persistence.

Literature Review

Inconsistent results have been reported regarding students' interest in pursuing careers in STEM. Some studies have suggested that students often make the decision to pursue STEM careers before high school (Wyss, Heulskamp, & Siebert, 2012), while others have found that high school students are seriously considering and becoming more interested in STEM fields (Kitchen, Sonnert, & Sadler, 2018). One study conducted by Sadler, Sonnert, Hazari, and Tai (2012) examined more than 6,000 students and found that interest in STEM fields at the start of high school was a key factor predicting STEM career interest at the end of high school.

Research has also been conducted on the factors that influence students' aspirations to pursue careers in STEM fields. Mau and Li (2018) examined over 20,000 9th grade students and found that those who aspired to STEM careers had significantly higher socioeconomic status and parental involvement, higher scores on math standardized tests, higher final grades in science courses, and higher math/science self-efficacy. Additionally, a study by Holmes, Gore, Smith, and Lloyd (2018) found that boys were more likely than girls to be interested in STEM fields, and that students' interest in STEM fields increased as they got older. Prior achievement in reading and numeracy were also significant predictors of students' aspirations to pursue STEM careers. Studies also showed that high school math courses are particularly important for minority students to persist in STEM in college (Ghazzawi, Pattison, & Horn, 2021).

To help develop interest in STEM fields, many universities have provided summer STEM outreach programs. Evaluation studies of these programs have shown that they can be effective in increasing knowledge, skills, and interest in STEM fields, and that participants of summer STEM programs are more likely to pursue careers and further education in STEM fields after high school graduation (Constan & Spicer, 2015; Kitchen, Sonnert, & Sadler, 2018). Studies also examined characteristics of effective summer STEM programs and suggested several strategies such as providing collaborative learning opportunities, offering faculty mentoring, and designing activities based on problem or project-based learning (Ghazzawi, Pattison, & Horn, 2021).

Program Design

The program is divided into two parts: a one-month-long Summer Academy and a Fall group project. During the Summer Academy, students learn various aspects of CS, such as software engineering, network security, and computer hardware, and also engage in coding using MIT App Inventor. We invited Black professionals who are working in the field of computing or education each week, and each guest shared the benefits of working in the computing field and tips for exploring future careers and college admission. Once they have acquired the basic knowledge and skills in CS, they work on a mobile app development project in the fall semester.

Participants

A total of 31 minority students participated in the study. There were 16 girls and 15 boys. In terms of race, there were two Hispanic and three Asians, and the rest of the students (n=26) were Black. There were 17 rising 10th graders, 12 rising 11th graders and 1 rising 8th grader, and 1 rising 9th grader.

Data Collection and Data Analysis

All participants were asked to fill out a pre and post survey examining their motivation for applying to the program, STEM identity, future careers, and program impact. We conducted an individual Zoom interview twice (i.e., pre and post-interviews). We also observed classroom teaching during the summer program and had many

informal talks during the break or lunchtime. We also facilitated online Zoom meetings in the fall semester on a monthly basis. Thematic analysis was conducted for the qualitative data (Thomas, 2006), and descriptive analysis was applied to analyze the quantitative data.

Results

Students' Motivation for Participation in the Program

The analysis of interviews and survey data revealed several components affecting students' motivation for applying to the CS camp, including (a) learning something useful (n=31), (b) curious about how programming works (n=27), and (c) enjoyment of science and technology activities (n=24). The comparison of multiple data also revealed that participants' interest in CS was influenced by several different factors: (a) family or peer recommendations, (b) exposure to early CS activities, and (c) confidence in math, science, or coding activities. For instance, Amy explained how her family and past CS experiences affected her STEM interest. She wrote in the pre-survey, "I've been interested in STEM for a while due to my interest in technology and math. My mom, a science teacher, helped me explore more about computers. When I was in about the 3rd grade, I participated in a summer program where we were asked to build a Lego robot and code it to make it move."

Impact of the Summer Program

The analysis of the post-survey showed that the Summer Academy helped boost students' interest in STEM and STEM careers. The post-survey asked participants to indicate the level of changed interest and abilities because of the program. Table 1 demonstrates that students' perception of STEM interest has increased compared to the first day of the program.

Table 1. Participants' Changed Interest and Abilities

Thinking about how you feel TODAY compared to the BEGINNING of this program:	Mean	SD
My interest in STEM	4.07	1.02
My ability to work effectively with others.	3.63	.90
My ability to engage in problem-solving.	3.67	.71
My communication skills.	3.80	.89
My motivation to learn new things	4.00	.83
My intention to enroll in more STEM-related courses.	3.97	.85
My confidence that I will be successful in STEM-related courses.	3.87	.86
My belief that I can improve my academic performance.	4.13	.81
My confidence that I can do the work required in my classes/school.	4.07	.82

Values: 1: much less now, 2: less now, 3: about the same, 4: more now, 5: much more now

Based on the analysis of their previous CS experience and general interest in CS, participants were classified into three groups. The first group had limited knowledge, experience, and interest in CS, while the second group had some experience and knowledge of CS, with a high level of interest in the subject. The last group included students with multiple CS experiences and high interest in the field. Despite their different levels of experience, the analysis of open-ended answers and field notes showed that the program helped all three groups of students learn more about CS and promote their interest in the subject. For example, Mandy, who aspired to be a traveling nurse, initially had little interest in learning CS, but after attending the program, her perception changed. In her post-survey, she wrote, "I think this program made me feel differently about computer science in many ways. Now, I feel like it is very interesting and seems like an awesome thing to do." During an informal interview, she revealed that she only applied to the program because her cousin asked her to do without much interest in CS, but she enjoyed the program and appreciated the opportunity to learn more about CS.

In contrast to Mandy, Anna had a positive experience with CS in elementary school, and her interest in the subject led her to join the program. She was thrilled to meet guest speakers and was inspired by their stories. After the guest speakers' visit, she reflected, "I think their stories helped me with my career. Hearing their stories made me want to go even deeper with my research in computer science. It made me feel like I picked the right career for

me." The program also helped students like Mark, who self-taught programming skills. In the post-survey, he indicated that the program helped him gain new knowledge that he did not know before. He said, "I've learned a lot of things such as the some of the Linux operating systems we used in the virtual machine. I also learned how to use the MIT app inventor more efficiently and how to code in there better than when I did before the program started."

Factors Affecting STEM Persistence

Although all but two of the participants expressed continued interest in CS, only half of them completed the Fall project where students designed a mobile app as a group. Therefore, the researchers investigated the factors affecting persistence in CS activities and found several factors affecting their decision to pursue fall CS activities. The first factor was STEM identity. The findings presented that students who completed the Fall project had a stronger STEM identity than those who did not persist. In terms of the identity factors, the overall mean for recognition was 3.17 (SD=1.15), interest was 3.75 (SD=1.05), and performance was 3.34 (SD=1.07). Table 1 summarizes the means and standard deviations (SD) for the persistence group and non-persistence group and presents the independent t-test results.

Table 1. Participants' Changed Interest and Abilities

	All Students	Persistence (N=16; Mean/SD)	Not Persistence (N=16; Mean/SD)	Sig*
Recognition	3.17 (1.15)	3.59 (1.11)	2.75 (1.09)	t=2.17 *
Interest	3.75 (1.05)	4.10 (0.91)	3.33 (1.06)	t=2.21 *
Performance	3.34 (1.07)	3.66 (1.05)	3.13 (1.02)	t=1.45

*p<0.5

Another factor was participants' general interest and prior experience of CS. While most of the high interest and high experience group persisted, the low interest and low experience group did not persist. Students' school environment appeared to affected persistence. The findings showed that a higher percentage of magnet school students participated in the program compared to those students who were attending low-income schools. Analysis of students' post interviews with the persistence group indicated that face-to-face meeting with group members helped them continue to participate. For instance, during the follow-up interview, Jane said that she and her partner attended the same school, and it helped them continue to check each other. She said, "Lisa, my team member, goes to my school, so we kind of just like remind each other that "Hey, we still got to work on the group project. We have been doing that." On the other hand, those group who depended on online communication shared difficulties of communication. Rebecca said "I think it would have been much better if we have done this part of the program during the summer. Even if that may extend the days and the amount of time each day, it would have been much more organized since we have someone there, assisting us and helping us and telling us what to do." Interestingly, there were five students who shared interest in continuing individual activities but only one completed the activities.

Finally, those students who continued to participate in the fall project commonly demonstrated strong self-determination. They explained that while there were many moments where they wanted to quit, they did not do it because they believe that they must complete activities if they start. For instance, Erika said, "After I commit to something, I really didn't want to quit. I know I have school, I'm sick, and I have a lot going on, but I joined this, and I said to myself, I was going to do it, and I'm going to finish this."

Conclusion

This study investigated the interest and persistence of minority and female students, specifically those from racial/ethnic minorities, in computer science (CS) activities by examining their motivation for applying to a summer CS program and identifying factors that affect their persistence in CS Fall mobile app development activities. The results of this study suggest that family encouragement and early exposure to CS activities influenced students' decision to apply for the program. Furthermore, students who continued to participate in the program demonstrated a higher level of STEM identity and strong self-determination. These findings provide evidence that providing CS

learning opportunities to minority students is critical in promoting their interest and persistence in CS activities. To help sustain students' interest in CS, it is recommended to provide continued support through face-to-face, in-school based activities.

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