Upward Bound: How Government Programs Increase Adolescent Interest in Computer Science

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Sadie Barton
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On my honor as a University Student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments

Rosanne Vrugtman, Department of Computer Science

ABSTRACT
Computer science is currently a male-dominated field in the United States, causing gender disparities in many technical, software-reliant products. Upward Bound Math/Science (UBMS) is a federal program that addresses this disparity by offering low-income, prospective first-generation college students support in the form of educational resources and experiences. The program requires high school-aged participants to attend a summer learning academy which randomly places them into block classes. One of these, robotics, trained enrollees about coding and computer science through the utilization of tools such as Arduino, technologies from VEX Robotics, and the ROBOTC language. My introduction to this course at age 14 caused me to develop a passion for the subject. The Upward Bound (UB) robotics class was so successful that it has been expanded to include both Robotics I and Robotics II. However, accessibility needs to be addressed so that more adolescents are aware of the program and opportunities available in the field of computer science.

1. INTRODUCTION
Many adolescents have no exposure to computer science or coding, leaving them unaware of the possibilities in the field. One program that is helping to change that lack of accessibility is the UBMS program. Upward Bound is one of the programs within the federally-funded TRIO programs, which provide educational outreach services and support to students from educationally disadvantaged backgrounds. TRIO students have disadvantaged backgrounds, are first-generation college students, low-income students or students with disabilities. Other TRIO programs include Upward Bound, Veterans' Upward Bound, Student Support Services, Talent Search, Educational Opportunity Centers, and the Ronald E. McNair Post-Baccalaureate Achievement Program. UBMS, UB, and Talent Search are designed for high school students (Hamm & Hexter, 2023).

2. BACKGROUND
My high school, Richlands High School in Richlands, Virginia, was a part of the UBMS program. The difference between the UB and UBMS programs is that the latter caters to the needs of students with a special interest in math or science. Due to the small population of the area, the UBMS program at my high school and neighboring high school was combined with the UB program at other neighboring high schools. The director, staff, and all the activities were the same for both programs. The summer program, mandatory for first-year participants and optional for all other students, was held at Southwest Virginia Community College (SWCC). The program consisted of six weeks of hands-on educational experience in various courses, followed by a fun field trip with additional experiences. While upperclassmen are allowed to indicate their preferences for courses during the summer program, first-year participants are given a random schedule consisting of one block class and a few elective courses.

For my first summer program, I was assigned robotics as my block class. I had not had any prior coding exposure and walked into the course with no prior knowledge of the subject area. My high school was located in one of the poorest counties in the state, Because the county had little funding for public education, students were not able to take many courses outside of those required for graduation. There was not enough teachers or funding to consider implementing a computer science program; we did not even have an AP program, as only one AP course could be offered in person with the one teacher certified to teach it. During this program, I was exposed to various tools, including Arduino,

technologies from VEX Robotics, and the ROBOTC language. Although I was first intimidated by robotics, over the course of the summer, I developed a passion for computer science.

Ultimately, this introduction to computer science at the age of 13 caused me to pursue a career in the field. If the accessibility of computer science could be broadened to all adolescents, many others would develop passions as well.

3. RELATED WORKS

Prior research has determined that mentoring has a notably positive effect on computing interest in adolescents. This means that having an adult mentor to guide and support a student through particular subject matter makes the student more likely to develop a positive relationship with the subject. Ko and Davis (2017) studied the effects of a Seattle-based UB web design course on students' impressions of computer science. They compared outcomes in a UB web design coding camp for low-income students with those of wealthier students in a similar program at a Seattle-area university, with a registration fee of $275.

At the beginning of the summer, all 44 students, aged 14-18, in both web design courses were surveyed regarding demographics, interests, academic plans, computing interest, and opinions of peers in computing. The study concluded that the web design course had a positive impact on students' interest in computing and self-efficacy. Notably, 5 of 11 students described substantially different self-outcomes which incorporated computing. One student went from wanting to be a doctor to wanting to study computer science first, then using the money from his computer science career to pay for medical school. Another student, who previously had no future plans, decided he would like to study both computing and aviation to improve equipment. A student with some previous web design experience but low self-efficacy left with much higher self-efficacy and the desire to become a computer science major. One student noted on her exit survey, "You definitely changed what I thought about computer science and web design. I love designing things, but I never thought one day I could design my own website in 6 weeks." Another student remarked, "This class helped me understand what jobs involved with tech would look like and how it's not just a lonely person in the basement" (Ko & Davis, 2017). Overall, the program notably improved students' perceptions of computer science and their self-efficacy with the subject matter.

4. PROCESS DESIGN

My summer 2014 UB robotics course lasted six weeks, Monday through Thursday, with optional field trips every other Friday. In addition to robotics, other courses included rollercoaster physics, forensic science and hot-air balloon design. The instructor for the robotics course was a woman with a great deal of experience with the subject matter. On the first day of the course, we all introduced ourselves, did an icebreaker, then talked about what robotics was. We were split into pairs and given a VEX robotics robot kit, instruction manual and tools for building our robots. At the end of the first block, we had all managed to build a small, simple robot, but we had not yet done any coding.

The after-lunch program included a 1-hour math class and two elective courses. My elective courses were Spanish and culinary arts. At the end of the day, everyone gathered in the auditorium for announcements, or college/career speakers.

On the second day, we were introduced to coding. Specifically, we were taught basic

syntax of the ROBOTC language and how to make use of it using Arduino. Next, we wrote a simple sample program to make the robot move forward by alternating the power of the motors. Then, we were taught how to upload it to the robot's "brain". After my partner and I finished our code and ran the program, causing the robot to move forward successfully, I was happy with what I had accomplished. Although it seemed a simple task, the idea of putting the pieces together and writing the code, all to create and manipulate something myself was exciting. The code was written from scratch, and at that moment, I realized coding was a blank canvas that could be used for many beneficial reasons. Additionally, it made me feel empowered because I had control over the robot with coding. After all pairs of students completed the assignment, we were given a brief quiz regarding the coding principles we had just learned. There were no consequences of doing poorly; these activities were solely for feedback.

Through the course of the summer, we expanded our project by adding sensors, including light and contact sensors, to our robots and programming our robot to complete new tasks, such as following a line of black tape on the floor. Although useful feedback was provided, most of the work was accomplished through trial and error, and I felt that the style of teaching and hands-on experience allowed me to develop a deeper understanding of the subject matter. Additionally, I enjoyed the competitive nature between groups to complete the task the quickest. The last thing we learned, at the end of the summer, was how to control the robot using an Android phone instead of manually-written code. The last day of the summer program was designated parent's day, and we all showed off our accomplishments to the community. Overall, the experience was enlightening and empowering.

5. ANTICIPATED RESULTS

It has been proven that adolescent exposure to computer science and adult mentors in the field has a notably positive effect on computing interest and self-efficacy in adolescents. This exposure is not accessible enough and many students remain unaware of the possibilities in computer science. Currently, the UB program in my area is limited to a certain number of schools and students. Additionally, there are a number of requirements to join the program, and the program typically only accepts academically gifted students in my region due to limited funding. If programs like this one were more accessible, more adolescents would be aware of the possibilities in the field of computer science and we could potentially begin to bridge the gender gap in the field.

6. CONCLUSION

The UBMS program provided me with exceptional insight into the field of computer science through the robotics course. At the beginning of the program, I had never been exposed to coding and I did not know what computer science consisted of. Throughout the summer, I developed a passion for the subject. The course taught me that computer science is not as difficult as I originally thought and that I certainly am capable of succeeding in the field. Most importantly, I learned that the possibilities are endless with computer science and there is an ocean of opportunities within the field. Had I not been placed in the robotics course, I might not have become a computer science major, because that was the only exposure I had to the field during adolescence.

7. FUTURE WORK

Prior research has shown that adolescent exposure to computer science has a positive effect on adolescents' perceptions of the subject as well as their self-efficacy related to

the subject. Furthermore, many of the students that participate in short-term computer science programs during adolescence, including myself and the students from Seattle, ultimately decide that computing is the career for them. As it is now, many kids simply do not have enough exposure to computer science to understand the subject or even consider pursuing a career in the subject.

Programs such as the UBMS robotics need to be expanded so that all adolescents are aware of the possibilities in the field. As mentioned previously, in order to participate in UB or UBMS programs, a student must be low-income, first-generation, and educationally gifted or disabled. Unfortunately, this leaves out a great number of students. Other programs, such as the coding camp in Seattle, are too expensive for many adolescents. Therefore, we need to find a way to make these programs accessible to all adolescents, regardless of academic ability or socioeconomic status. A good first step would be to ensure that every public high school has an introductory computer science course or, at minimum, a dedicated club.

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