Engineering for the Future: Mississippi State University's Cyber Summer Programs

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Abstract

The Computer Science and Engineering (CSE) department at Mississippi State University (MSU) has offered summer camp experiences for middle and high school students since 2011[1]. In 2015, Mississippi State University hosted four summer computer science camp experiences for high school and middle school boys and girls with diverse socioeconomic backgrounds and technological proficiencies. Middle and high schoolers of the same gender attended the same week to encourage communication, mentorship, problem solving, and teamwork between age groups and within genders. The theme of all four camps was personal safety in an online environment, and campers were introduced to computer programming, cyber security, and digital forensics. This was the second summer CSE piloted an interdisciplinary approach to computer science education by collaborating with the departments of Art, English, and Education to design, implement, and assess the camp. This paper discusses the camps and includes campers' feedback about their experiences.

Keywords

Engineering education, robotics, computing, cybersecurity.

Background

A diverse and flexible workforce capable of working across boundaries—including those created by class, gender, and race as well as location and discipline—is increasingly necessary for the United States to respond effectively to the challenges posed by an electronic and technological society. Both engineering and humanities ("soft") skills will be key to navigating the sociotechnical challenges of the future. Similar to addressing the challenge of providing internet access and education in rural areas, addressing the sociotechnical challenges—both to personal information and national security—that accompany widespread internet access and education is equally important. Critical to success will be diversifying the technically skilled workforce in terms of race and gender and better preparing students to enter careers that require technical as well as communicative, collaborative and management competencies. The interdisciplinary MSU Bulldog Bytes team works to reshape perceptions of computer scientists and engineers for the next generation; thus, the camp strives to make the path to and through engineering education welcoming and accessible to all persons.

Our interdisciplinary approach recognizes that preparing students for life and careers in the 21st century means engaging them in thinking about technology and computing from a variety of dimensions. The digital world we live in requires new skills and behavior to ensure technology is used responsibly and safely. Often, users of technology do not perceive the consequences of

actions they take online and the impact of the anonymity in cyberspace. Students learn cybersecurity concepts through a curriculum that blends robotics, programming, and the liberal arts. Cybersecurity lessons include learning about threats in cyberspace and mechanisms for protecting personal safety. Introducing the students to digital forensics enables them to recognize the digital footprints they leave on computers, cell phones, and during any electronic transactions.

Same-gender camps are hosted, recognizing that girls are more engaged with STEM curricula without the distractions and stereotypes that come in mixed gender learning experiences[2]. The summer camp offerings provide an environment that enables us to better understand how learning environments can introduce girls and women to technology in ways that do not alienate them and that counter the stereotypical messages they get from media, video games, and other cultural artifacts. In our boys camp, we engage participants in this discussion, recognizing that to establish an equitable workplace, it will take the cooperation of both genders. Making boys aware of the fact that girls are less interested, not less capable, of entering STEM paths is the first step in inviting them to be a part of ensuring a gender equitable technological workplace.

Camp Overview

Four residential camps were offered during the summer of 2015 on MSU's Starkville campus. Camps for rising ninth through twelfth graders were five nights, while students entering grades six through eight stayed four nights. The middle school and high school aged camps overlapped for each gender. In 2015, 77 out of 154 applicants were invited to attend the camps free of cost: 18 middle school boys, 21 high school boys, 20 middle school girls, and 18 high school girls. Camper selection was based on a personal statement on the application form. Applicants whose personal statements showed a clear interest in computers, cyber security, programming, and technology as well as beginner- or intermediate-level experiences in such areas were given preference. Applications, participants, and completion numbers are shown in Table 1. One student left the middle school girl camp mid-week due to a family emergency.

Table 1. Applicant and Camp Participant Numbers.

	Middle School Boys	Middle School Girls	High School Boys	High School Girls
Applicants	26	37	54	37
Enrolled	18	20	21	18
Completed	18	19	21	18

Camp staff during each week included two near-peer counselors, both alumni of previous camp offerings. Ten college-age counselors were employed to provide instruction and to reside in the dorms with participants. One of the undergraduate female counselors, with three years of MSU camp leadership experience, served as the program director. Another undergraduate counselor had been an MSU CSE camp participant when she was in high school. Both female and male counselors were employed each week, with only the gender appropriate counselors residing in the residence halls.

To introduce participants to the types of careers possible with a computing education, guest speakers were invited from industry and government agencies. These included representatives from the National Security Agency, International Paper, and Computer Medics of North Mississippi. Speakers from on-campus offices were also engaged, including a staff employee of the Distributed Analytics and Security Institute (DASI) who led instruction on cybersecurity and digital forensics. A visually impaired employee of the National Research Training Center on Blindness & Low Vision shared the impact of accessibility requirements for technology systems. Pictured in Figure 1 is Regina Reed, owner of Computer Medics of North Mississippi, meeting with middle and high school girl participants.

Figure 1: Regina Reed, owner of Computer Medics of North Mississippi.

Of the 77 selected camp applicants, 65 agreed to participate in research at the camp. Fifty-five participants agreed to participate in longitudinal research that will use follow-up interviews to track the kinds of computing, engineering, and technological opportunities participants engage in over the next five years. Table 2 represents the demographics of campers who agreed to participate in research and whose exit survey responses are sampled to represent camper feedback about their experiences at Bulldog Bytes.

Table 2. Research Participant Demographics.

	Middle School Boys	Middle School Girls	High School Boys	High School Girls	Total by Race
African American	3	9	7	9	28
Asian	2	2	0	2	6
Mixed Race	1	1	1	0	3
White	8	6	10	4	28
Total by Age	14	18	18	15	

Curriculum Approach

In roughly five days, campers learned to program using robots; to think critically about the notion of security in a cyber-age through digital forensics demonstrations and case study projects; and to work as teams to create and decode encrypted texts. Campers also worked in groups led by computer science and software engineering undergraduates to develop applications and a scenario or script that they then programmed robots to navigate. Programming languages and robots varied across age group. Additionally, campers who chose to participate in research spent time in discussion groups talking about gender and race in relation to issues regarding underrepresented groups in the technology domain.

All campers were introduced to basic principles of computer programming by using App Inventor[3] and a simple drag-and-drop interface called SNAP![4]. The middle school groups followed a group tutorial to build a mini-golf app. The high school groups were given the freedom to be creative and design an app of their choosing with App Inventor. Campers designed a variety of applications, including a trigonometry calculator.

Middle school campers continued working with SNAP! as they advanced from programming in App Inventor to programming for the Finch robot[5], as shown in Figure 2. High school campers moved into more advanced programming, using the C programming language with ActivityBots[6], pictured in Figure 3. The ActivityBots were different from the Finch in that they had to be assembled before they could be programmed.

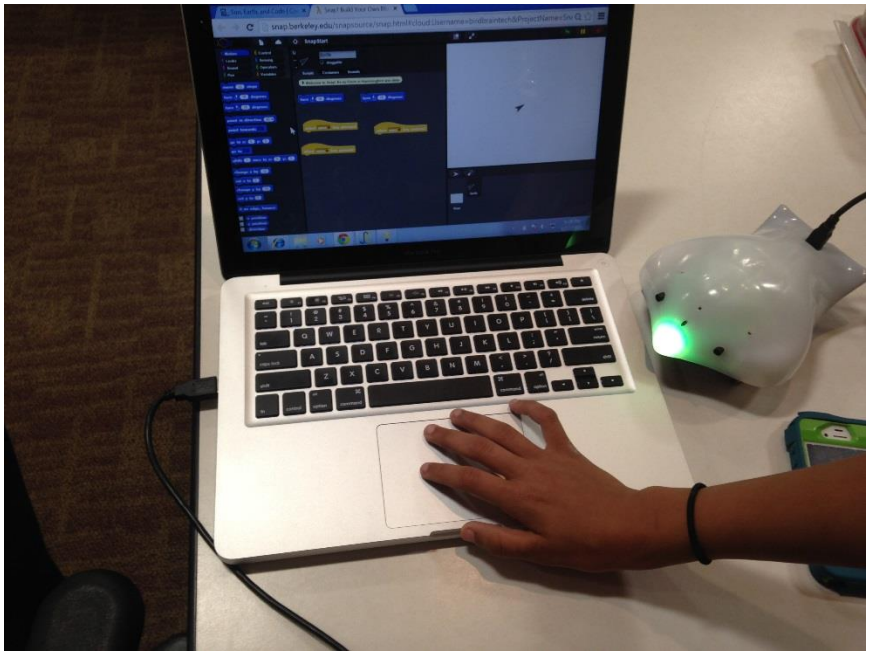

Figure 2: Snap! interface and Finch robot.

Figure 3: High school participants with ActivityBots.

Since the middle school and high school camps overlapped, joint activities were held to encourage near-peer mentoring. One example was having the high school students interact with the middle school students on the robot design project. More experienced campers were able to suggest design improvements for some of the novice teams as demonstrated in Figure 4.

Figure 4: High school campers joined middle school campers to provide design expertise.

A guided lecture followed by hands-on activities using Access Data FTK Imager[7], Opanda IExif[8], and echosec[9] introduced data mining and digital forensics concepts. To explore cryptography, male campers learned how to create ciphers with sliding scales and female campers participated in decoding team challenges. All groups participated in team-based, competitive QR code scavenger hunts that led them across the MSU campus.

Activities were organized to provide cross-group collaboration in addition to modules separated by age group. High school students checked into the residence hall on a Saturday and camp activities began for them before the middle school participants arrived on Sunday afternoon. Camp activities included formal curricular instruction, hands-on experimentation, project drafting and storyboarding, team challenges, and team projects. Camp activities also included informal team-building activities (like video games and rock climbing) as well as free time to allow campers to network and socialize with or without technology. Female participants are shown in Figure 4 playing video games during one of the evenings.

Figure 4: Female participants bonding over video games.

The cross-group collaborative approach is illustrated by a section of the camp schedule shown in Table 3. Robot projects were demonstrated to family members on Friday with a joint closing ceremony that recognized camp participants and counselors for outstanding work. Middle school students took their Finch robots home with them to encourage informal learning and to extend the reach of the camp. The approach was used in previous summer camps[10], and one participant from 2014 brought her Finch back to get further assistance with technical challenges she encountered at home.

Table 3. Camp schedule excerpt

TUESDAY			
High School		**Middle School**	
8-9	Breakfast	8-9	Breakfast
9-11	Intro to Cybersecurity	9-9:45	Open Lab time with App
		9:45-10	Break
		10-11	Intro to Finch Robots &
11-12	Intro to ActivityBots & Project	11-12	Finch Robots
12-1	Lunch	12-1	Lunch
1-2	Intro to C & ActivityBot	1-2	Finch Robots
2-2:15	Break	2-2:15	Break
2:15-3:00	Intro to C and ActivityBot	2:15-3:00	Finch Robots
3-4	Intro to Cryptography	3-4	Intro to Cryptography
4-6	QR Code Scavenger Hunt	4-6	QR Code Scavenger Hunt
6-9	Hamburgers, Hotdogs, and	6-9	Hamburgers, Hotdogs, and
9-11	Free Time	9-11	Free Time
WEDNESDAY			
8-9	Breakfast	8-9	Breakfast
9-10	Speaker	9-10	Speaker
10-12	Robot Work	10-12	Intro to Cybersecurity
12-1	Lunch	12-1	Lunch
1-4	Digital Forensics	1-2	Code Academy: Open Lab
		2-2:15	Break
		2:15-4	Finch Robots
4-5	Encrypted Messages: Team	4-5	Encrypted Messages: Team
5-6	Dinner	5-6	Dinner
6-8	Gym activities	6-8	Gym activities
8-11	Free Time	8-11	Free Time

Camper Feedback

Pre- and post-surveys were administered to collect student perceptions of the effectiveness of the camp, and informal feedback was provided by independent observers which included representatives from funding sources and K12 teachers from the state of Mississippi. Teachers observed twice during the girls' week, once when robot project teams were constructing obstacles and game scenarios and again at the end of the camp for the project demonstrations. Preliminary data from post-camp survey responses is presented below.

Campers took exit surveys the morning before finalizing their project demonstration approaches. For the second year in a row, 89% of campers reported in the exit survey that the camp met their expectations. No campers indicated that they did not learn what they intended to at the camp; however, some chose to check neither yes nor no and instead explained:

- "Yes, but not in the way I was expecting."
- "I did not know what I was going to be learning."
- "OF COURSE."
- "I learned some stuff I wanted to and some other stuff I didn't expect to learn."
- "I learned more than I expected."
- "I really did not hope to learn a specific thing."

A sampling of responses from participants to the question "What did you learn at the camp?" are shown in Table 4. Programming, robots, cybersecurity, and career options were prominent in camper responses.

Table 4. Sampling of responses to "What did you learn at camp?"

High School Boys
• The basics of programming, forensics, and cyber security. • I learned how accessible my info is. • I learned that no matter what you do, you will leave a cyber footprint. • I became more knowledgeable about jobs to do with computer science, and the various ways to use programming. • I learned some coding. I also became more informed about the expanding fields of cybersecurity, forensics, and cryptography. App Inventor was an interesting activity, as I now can utilize it. From designing an app, I have become much more familiar with trigonometry.
Middle School Boys
• I learned about programming, cybersecurity, teamwork, and robots. • The basic principles of programming robots and a lot about cyber security. • I learned how to program both Apps and Python [with] robots, as well as learning of cybersecurity and its function in the world. • I learned a lot more about forensics. And how to make an app. • I learned about the different types of hackers.
High School Girls
• That I do want to work with computers in the future. • I learned about cyber security and forensics which is really cool. You can use different programs to see where pictures were taken & when they were taken. It's like you're solving a mystery. Also learned C code. • I learned the process people in digital forensics use, the programs, and jobs that you can get in that area. I also learned how to code in C and with cryptography. • I learned how to send messages with codes only you and the person you want to can see. I learned how to program and make an ActivityBot draw polygons. I learned that you can study anything you want and be good at it by putting work towards it.
Middle School Girls
• How to code, do forensics, make an app, program a robot, and cryptography. • I learned about coding and decoding …., and I also learned forensics and cyber security. • I learned how to use the computer in a smarter and safer way. • I learned a lot about technology, such as forensics, cybersecurity, working with robots, working better in groups, and more that I really enjoyed.

Future Plans

Based on feedback gathered from K12 teacher observations, faculty from the MSU Education department will join the team next summer to provide teacher institutes for K-12 teachers.

While the ActivityBots were effective for programming instruction, there were parts that could be easily broken off and lost which contributed to the decision prior to the camp to not send those home with campers. Additional robotic technology is under investigation by the project team that will enable all campers to take home a robot for extended learning and knowledge sharing with peers. Sphero[11] robots appear to provide sufficient technical challenge and opportunity for creative design and are under evaluation by the project team.

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