A Comparison of Two Hands-On Laboratory Experiences in Computers, Networks and Cyber Security for 10th-12th Graders

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ABSTRACT

In this poster, we describe our experience of designing and executing two different weeklong programs for 10th – 12th grade students. The goal of our program is to attract students to the field of computing, increase their computing confidence and familiarize them with ways that computing impacts our community. Student groups consist of 32 students for each week with a 1:0.8 male-to-female ratio. No prerequisite knowledge is required to attend. We compare the different facets of the curriculums by evaluating the impact of each week both quantitatively and qualitatively. Our evaluation implies the attraction of cyber security topics to this age group, particularly male students, and presents a curriculum that may help increase confidence in computing concepts, particularly for female students. We solicit feedback and welcome input on our curriculum and evaluation method.

1. SIGNIFICANCE AND RELEVANCE OF TOPIC

Several initiatives such as Computing Education for the 21st Century (CE21), CS10k and STEM-C Partnerships seek to build a future workforce with that is "computationally savvy" and contribute to our nation's presence in the global economy as well as the national security[1].

The U.S. Army Education Outreach Program (AEOP) established the Gains in the Education of Mathematics and Science (GEMS) Program. GEMS consists of a set of weeklong summer programs designed to engage students and teachers in Science, Technology, Engineering, and Mathematics (STEM) in an applied environment. GEMS provides outreach opportunities that connect practicing scientists and engineers with middle and high schools students for a hands-on-laboratory experience. It is sponsored at more than 15 different Army laboratories, including Aberdeen Proving Ground.

In the summer of 2013, we conducted a pilot program for 10th-12th graders focusing on computers, networks and cyber security. We assumed that both creative computing projects and cyber security topics would be appealing to the students and perhaps attract them to the field of computing. The program was advertised as a week long experience in Computers, Networks and Cyber Security without details of each week's curriculum. Students applied to the program through the AEOP website and received a stipend of $100 for the week. In addition to GEMS instructors which are practicing scientist, engineers, and technicians, two school teachers and 5 college students were employed to help facilitate, teach, and observe the program through daily reflections.

2. CURICULUM

The two 1-week programs, designated as Week A and Week B, had different curriculum, instructors and students but the same observers. Both programs highlighted the connection and impact of science and our Soldiers.

Topics presented in Week A primarily focused on computer networking and cyber security fundamentals and culminated in a group digital Easter egg hunt to reinforce concepts presented during the week. At the end of the week, student groups presented predetermined topics in a review of the week presentation to parents and other interested parties. The themes for Week A included basic computer networking concepts (routing, services, client server programming), general cyber security principles (confidentiality, integrity, availability, non-repudiation, ethics), and more advanced cyber security concepts (digital forensics, cyber attacks, mobile device security). With this foundation, students participated in a full day, role playing exercise encompassing all the skills they learned throughout the week. The exercise was in the form of a digital egg hunt where an imaginary bowling ball manufacturing company hired the students as cyber security auditors to assess the security of its network and discover clues that could uncover how the fictional company's competition always seems to be one step ahead. The exercise involved network mapping, wireless network penetration testing, digital forensics, message deciphering, and even social engineering. At the end, teams prepared and presented manager-level briefings explaining their findings to the CEO of the bowling ball company. In addition to the technical topics, Week A included an leadership and communication track with lectures and exercises in topics such as communication and leadership, public speaking, computer mediated communication and social media and understanding the STEM job market.

Week B focused more broadly on computing concepts and contained an outreach assignment and student selected creative project. Programming was included using the pair programming method [2] [3]. The themes for Week B included Computers (CS unplugged Activities, Hardware dissection), Programming via Paired Programming (Picoblocks, Scratch, Python), Security (cryptography, ethics, and basic cyber security) and Networks (network routing, and Network traffic sniffing via Wireshark). Students paired into self-selected groups and chose a team project choosing from the following options: scratch/python programming on the Raspberry Pi, robotic platforms (Pico-crickets/Lego NXT Mindstorms), electrical circuits (Snap-Circuits), and e-textiles microcontroller (Lilypad Arduino). At the end of the week student teams presented flash talks (3 minutes each) followed by an open interactive session where student could demonstrate their project to small groups of participants (other students, instructors and family members). Early in the week, several Army scientists presented their projects on various platforms in the same format (flash talks and interactive demonstration) so that students would be familiar with this format. In addition, we asked students to perform an outreach lesson were they taught a short lesson to someone, perhaps a family member, on a topic of their choice that they had learned earlier in the week [4].

Our poster will describe session topics, duration and teaching technique along with comments and notes on session. There were common elements for both weeks. For instance, both weeks utilized feedback mechanisms such as Stop-Start-Keep Exit Tickets for the first 2 days, team building activities facilitated by college facilitators during lunch and break times (e.g., Frisbee, foursquare ball). Furthermore, the leadership session from Week A relating to the STEM job market was replicated for Week B.

3. Evaluation

To help measure the impact of our differing curriculum, we use both quantitative measure captured by a pre and post survey along with qualitative observations and reflections by facilitators. Surveys consisted of a simple one-page questionnaire given to each student at the start of the week and prior to student presentations at the end of the week. The survey captured gender and grade demographics and contained five questions using a Likert Scale to measure attitude [5].

3.1 Quantitative Evaluation

To increase accuracy of responses, the Likert Scale was illustrated using smiley faces on our one-page survey. Questions were selected to try to capture the impact of the experience corresponding to the goals of the program and to attempt to differentiate the weeks. We group the question into excitement (Q1 and Q2) and confidence (Q3-Q5):

Q1: How excited are you about computing/computer science/computer security?
Q2: Do you intend to explore a career involving computing?
Q3: I am confident that l can teach myself a new programming language.
Q4: I am confident that l can teach technical computing concepts to others.
Q5: I am confident that l understand of the impact of computing in our community today.

Since Week A and Week B contained a different set of students with their own bias, we establish a starting point for attitude by showing a comparison of pre and post surveys for both weeks in Figure 1. In this figure, the gender groups are combined for the respective weeks.

In an attempt to quantitatively measure the impact on attitude, we will show the difference between pre and post survey average for the Likert Scale values for each question. The survey responses were anonymous in an effort to promote accurate survey results. This prevented us from tracking impact for individual students; however we were able to preserve values for gender groups. For instance, a positive Likert Scale change indicates an increase in positive attitude for a gender group while a negative Likert Scale change indicates a decrease in positive attitude for the group.

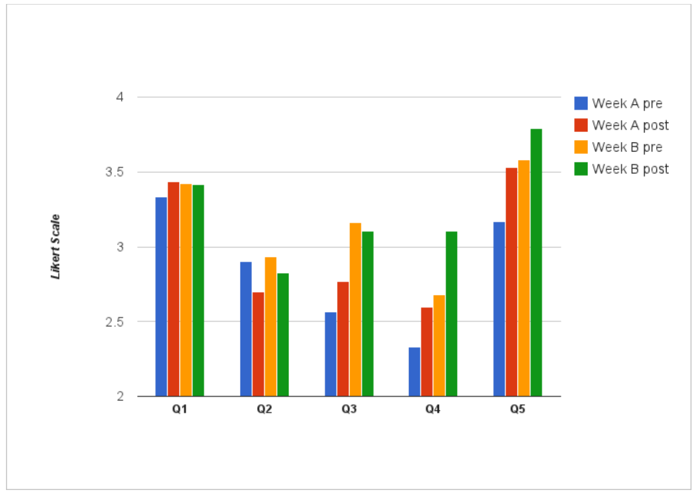

Figure 1. Pre and Post Survey Results

3.2 Qualitative Evaluation

As part of our program execution, five college-aged students and two school teachers (one middle school and one high school) were employed to function as enablers and observers. All have some background in computing fields. The high school teacher has experience teaching AP computer science and the middle school teacher had experience with robotic clubs. All observers recorded daily reflections for the two weeks of the program with specific instruction to note areas that should be improved. These reflections were used to construct the qualitative assessment presented in the poster.

4. Objective of Poster Session

We believe our material is well suited to a poster session and the potential exchange of ideas with professionals in the field of computing education would be beneficial to our program in the future.

5. Bibliography

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