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Effects of a Four-Week Cyber Security Summer Program on the Attitudes and College Interests of High School Students

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Abstract - Encouraging the next generation of cyber security professionals through outreach programs is a vital component of cyber security education. Competitions and short-term summer camps have previously been shown to have a positive impact on students' attitudes towards cyber security. As part of a NSF Scholarship for Service (SFS) grant, a four-week summer outreach program with intensive hands-on activities was created at California State University, Bakersfield to encourage high school students to pursue cyber security related college majors. Pre-surveys and post-surveys with attitudinal questions were used to assess the effect of the program on students' attitudes and college interests. The majority of participants indicate that the program increased their interest in cyber security. However, there is a gender gap for interest in college majors, with male students being far more likely to consider a cyber security related college major both before and after participating in the program.

Categories and Subject Descriptors

K.3.2 [Computers and Education]: *Computer and Information Science Education – Computer science education*

General Terms

Education, Outreach, Security

Keywords

Education, Outreach, High School Outreach, Summer Program, Security, University

1. INTRODUCTION

Cyber security outreach is a critical component in encouraging high school students to pursue college programs that train the next generation of cyber security professionals. While competitions and short-term summer camps have been effective outreach tools in the past [1] [2] [3] [4] [5], they can suffer from a self-selection bias, where students who have an existing interest in cyber security are more likely to participate. This can skew the demographics of the participants, which makes it difficult to apply the results to a wider audience.

California State University, Bakersfield (CSUB) is a public university serving a region with a diverse population and historically low educational achievement. The university has focused on improving educational opportunities for students in the region, particularly for underrepresented minorities and women in STEM.

CSUB has a long-standing four-week STEM summer program for high school students, Research Experience Vitalizing Science – University Program (REVS-UP), that has been effective at changing students' perceptions about college. CSUB applied for and received a capacity building grant from the NSF Scholarship for Service (SFS) program in October 2012. One of the main grant activities was to build a four-week summer program for high school students, using REVS-UP as a model.

The summer program immerses the high school students in cyber security education and research through hands-on projects, discussions, and group activities. In order to gauge the effect of the program on student attitudes towards cyber

security and interests in college majors, a pre-survey tool was administered at the start of the program and post-survey tool was administered at the end of the program.

In section 2, the summer program is described in more detail. Section 3 gives a brief overview of related prior works in assessing attitude changes and effectiveness of cyber security outreach programs. The pre-survey and post-survey tools are described in Section 4. The major findings about the effect of the program on attitudes and interests are presented in Section 5. The main conclusions drawn from this program are given in Section 6 and Section 7 discusses potential future work in this area.

2. SUMMER PROGRAM DETAILS

As previously described in [6], the summer cyber security program was a four-week activity which met all day on Mondays through Thursdays on the CSUB campus. CSUB is closed on Fridays during the summer, so the program did not meet then. Three instances of the program were hosted over a period of three years. The program was modeled after other programs that have been shown to provide effective STEM outreach [7] [8] [9] [10] [11] [12] [13]. The program was also modeled after the existing STEM outreach program, REVS-UP, at CSUB.

The cyber security program was co-hosted with REVS-UP so that the high school students and teachers participating in the cyber security outreach program could interact with peers in other STEM disciplines. Additionally, high school students submitted one application for both programs, instead of having to submit multiple applications. While this application did allow students to state a preference for specific topic areas, students were first accepted to the program based on their academic performance relative to the other applicants from their specific high schools and then placed within a specific topic area. Since students are applying to the broad STEM and cyber security summer program as a whole, this minimizes the self-selection bias that can be seen in cyber security competitions and summer camps, where only students interested in cyber security apply.

The summer program was divided into two sections: one focusing on cryptography and one focusing on general cyber security topics. The cryptography section was led by the co-PI for the SFS grant and the general cyber security topic section was led by the PI. Each section aimed to have 10 high school students and 1 high school teacher participating. There was also at least one upper-division student from CSUB in each section. The university student acted as a peer mentor to the high school students.

The purpose of the activity was to give students hands-on experiences with cyber security topics. Since this was a new area to most of the high school students, the first week was spent introducing concepts and acclimating the students to the tools and techniques being used. The majority of the second and third weeks were spent working on their hands-on projects. Some of the time in the morning was also spent talking about major cyber security incidents of past and present, and the lessons that can be learned from those incidents. At least one morning each summer was spent discussing cyber security and technology careers, and the need for more trained professionals across academia, industry, and government. The fourth week was spent preparing a poster for a poster session on the afternoon of the final day. The poster session was co-hosted with REVS-UP and the students' families were strongly encouraged to attend. More specific details of the program schedule can be found in [6].

3. PRIOR WORKS

In Turner et al. [5], the effectiveness of a cyber camp program on the attitudes and interest of high school students, particularly female students, was assessed. The camp was a one-week residential program held in the summer which teamed high school students and teachers with university faculty. They found that the camp increased perception of cyber value among female participants and a decreased perception in value among male participants. While this program involved high school students and high school teachers in a summer camp, it significantly differed in approach, as it used a wide variety of projects over a short period of time.

Several prior works [1] [2] [3] [4] have assessed the effect of cyber security competitions on participants and their career choices. These participants include college-level students and high school students. Of the high school students surveyed by Bashir et al. in [3], slightly more than 40% of the respondents said the competition positively influenced their interest in pursuing cyber security careers. Bashir et al. have also investigated the effect of personality attributes and vocational interests on career interest in [1] [2] [3]. Cyber security competitions are a popular method of outreach to students, but do not correlate to the activities of this program.

4. SURVEY DETAILS

A pre-survey was administered at the start of the program, after completion of consent and ascent forms by the high school students and their parents/guardians. The post-survey was administered at the beginning of the last day of the activity, so students could go directly home from the poster competition in the afternoon of the last day.

The pre-survey consisted of a background information section and an attitudinal section. The background information collected was the high school preparation in math and science, participation in previous STEM activities, high school level just completed in spring, gender, and race/ethnicity. The attitudinal section consisted of open-ended questions, Likert scale questions, and the student's interest in various college majors, as listed in Table 1.

Pre-Survey Question	Answer Type
What interested you about this summer activity?	Open-ended comment
What do you expect to learn and experience during this activity?	Open-ended comment
I am excited about this topic area.	Standard Likert scale
I feel confident that I am prepared for this activity.	Standard Likert scale
I am interested in computer security / cyber security.	Standard Likert scale
I am interested in cryptography.	Standard Likert scale
I am interested in going to college.	Standard Likert scale
What college majors are you interested in? Select all that apply.	Choose from list

Table 1: Pre-survey attitudinal questions. The standard Likert scale questions were rated on a scale of 1-5 where 5=strongly agree, 4=agree, 3=neutral, 2=disagree, and 1=strongly disagree.

The post-survey consisted of an attitudinal section and an activity satisfaction section. The attitudinal question on the post-survey had matching questions to the attitudinal questions on the pre-survey. To counteract the tendency for people to answer ‘agree’ or ‘strongly agree’ on the pre-survey, leaving little room to determine the effects of the program on attitudes, a set of reinforcement questions were added to the post-survey. The reinforcement questions asked students to self-

assess their change in interest level. The attitudinal post-survey questions are given in Table 2.

Post-Survey Question	Answer Type
What did you like about this activity?	Open-ended comment
What specific knowledge and/or experiences did you gain from this activity?	Open-ended comment
I am excited about this topic area.	Standard Likert scale
I was prepared for this activity.	Standard Likert scale
I am interested in computer security / cyber security.	Standard Likert scale
I am interested in cryptography.	Standard Likert scale
I am interested in going to college.	Standard Likert scale
What college majors are you interested in? Select all that apply.	Choose from list
Rate the effect this activity had on your interest in computer security / cyber security.	Reinforcement Likert scale
Rate the effect this activity had on your interest in cryptography.	Reinforcement Likert scale

Post-Survey Question	Answer Type
Rate the effect this activity had on your interest in attending college.	Reinforcement Likert scale
If your interest in any of the above areas has decreased, please give a brief explanation why.	Open-ended comment

Table 2: Post-survey attitudinal questions. The standard Likert scale was 5=strongly agree, 4=agree, 3=neutral, 2=disagree, and 1=strongly disagree. The reinforcement Likert scale was 5=much more interested, 4=more interested, 3=no effect, 2=less interested, and 1=much less interested.

5. SURVEY RESULTS

Over the three years of the summer program, 60 high school students were accepted to the program, but only 51 students actually participated in the program. Of those 51 participants, 45 completed both of the surveys. The remaining 6 students either did not complete the consent and ascent forms or did not complete both surveys.

Overall satisfaction with the program was high. The average satisfaction with the faculty mentor was 4.68 out of 5 and the average satisfaction with the undergraduate student serving as peer mentor was 4.91 out of 5. Additionally, 44 of the 45 respondents said they would recommend the program to their friends.

5.1 Participant Demographics

The high school rankings for participant high schools, according to current GreatSchools.org data, ranged from a high of 9 out of 10 to a low of 4 out of 10. Approximately one-third of the participants came from a school ranked 6 or lower.

With respects to gender, 44.4% of the participants (20 students) were female and 55.6% of the participants (25 students) were male. The race / ethnicity

demographics of the respondents, as shown in Figure 1, was diverse and reflects the demographics of the Southern San Joaquin Valley region of California in which CSUB is located.

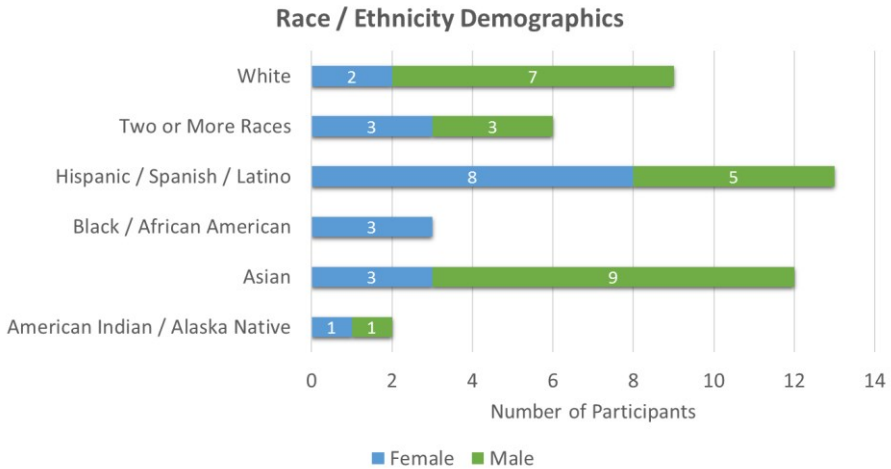


Figure 1: Race / ethnicity demographics for the high school students who participated in the surveys.

In contrast with the results of Bashir et al. [3] and Tobey et al. [4], the students participating in this program showed a greater level of diversity. Bashir et al. had less than a 12% female response rate and Tobey et al. had a less than 15% female response rate. Underrepresented minorities were also underrepresented in both survey populations. Since their works draw on surveys of cyber security competition participants, their population of potential respondents has already gone through a self-selection phase that can skew the demographics. This program was heavily advertised to local high schools and attracted a wide range of participants.

The gender demographics of this program were similar to those of Turner et al. [5], but this program had a higher percentage of underrepresented minorities participating. Less than 15% of the participants described in Turner et al. were underrepresented minorities, while slightly more than half of the participants in this program were underrepresented minorities. The demographics of high school

student respondents for this program closely match the demographics of undergraduate students at CSUB. This is expected, as CSUB primarily draws students from local high schools, where participants in this program were also recruited.

Students were also asked about their high school level and background. Slightly less than half of the participants had just finished their junior year, approximately 30% had just finished their sophomore year, and approximately 20% had just completed their senior year. The mathematical preparation at the high school was strong. All of the students had completed high school geometry, 44 of the 45 students had completed algebra 2, and 31 of the participants had completed math analysis/pre-calculus.

5.2 Attitudinal Changes

There were five matched Likert questions on the pre- and post-surveys, and reinforcement questions on the post-survey relating to interest in cyber security, cryptography, and college. The responses to the matched questions, separated by gender, are given in Figure 2. There was no change between the pre-survey and the post-survey on the matched question regarding interest in college because almost all of the students answered ‘strongly agree’ on both the pre- and post-survey, so this question was not included in Figure 2.

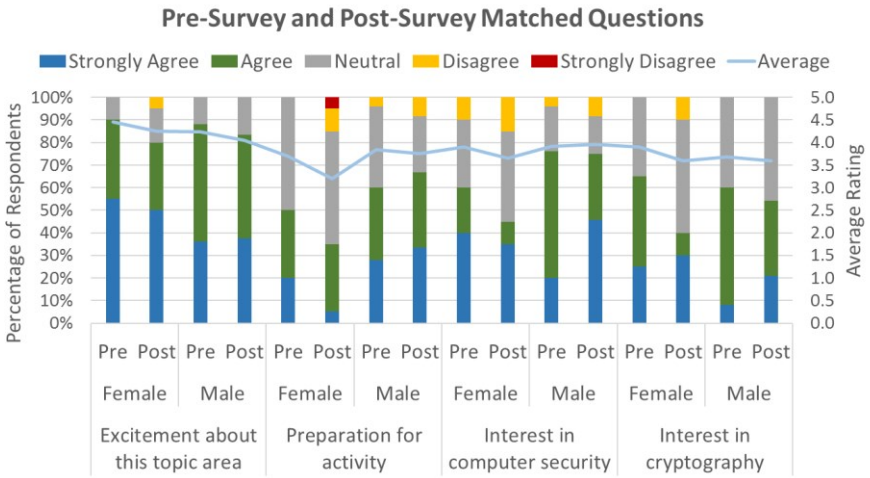


Figure 2: Likert scale responses on the four matched pre- and post-survey attitudinal questions broken down by gender.

The reinforcement questions were designed to capture potential changes that could be lost when students answered ‘strongly agree’ on the pre-survey, thereby leaving no room for improvement in the matched questions on the post-survey. The reinforcement questions ask for a self-assessment of change in interest. The responses to the reinforcement questions, also separated by gender, are given in Figure 3.

Several trends are observed in this data. Excitement about the topic area had a slight decrease for both male and female participants by the end of the program. This change was not significant. A closer look at the survey data revealed that a couple of participants who did not have a good experience in the program were the primary drivers for this decrease.

A larger percentage of male students answered ‘strongly agree’ or ‘agree’ for the matched questions related to preparation, interest in computer / cyber security, and interest in cryptography on both the pre-survey and the post-survey. Female students in particular were more likely to report that they did not feel adequately prepared for the program on both surveys. It is unclear from the open-ended

comments if this is due to a true lack of preparation or if it reflects a lack of confidence. Also, as a result of the intensive hands-on nature of the program, students may become more aware of what they don't know during the course of the program, resulting in a lower response on the preparation question in the post-survey.

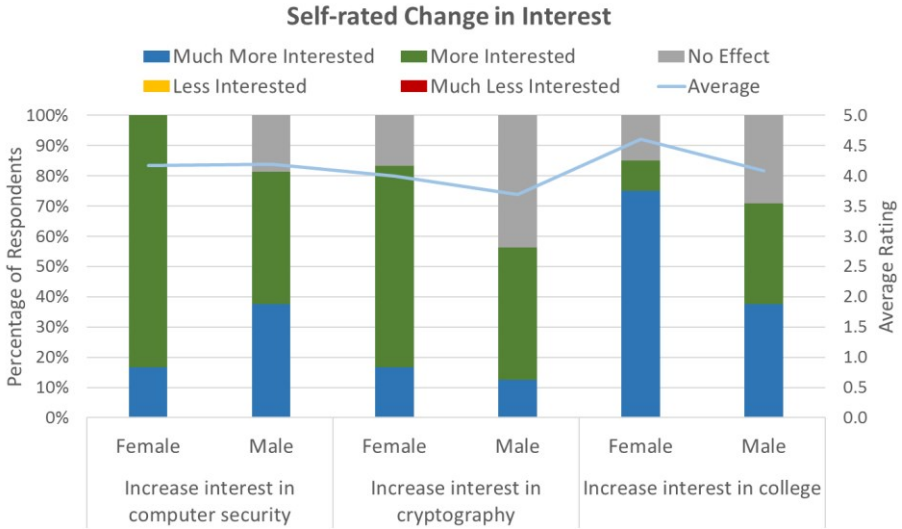


Figure 3: Responses to reinforcement attitudinal questions on the post-survey, where participants self-assessed their change in interest. Responses are broken down by gender.

For interest in computer / cyber security, male students had a slight increase in interest and female students had a slight decrease in interest on the matched question. However, on the reinforcement question, all of the female students said the program increased their interest in computer / cyber security, while only 81.3% of the male students reported an increase in interest.

A similar trend was observed with the student interest in cryptography. Also, more female students reported that the program made them “much more interested” in college than the male students. This indicates that the program is having a positive effect on both male and female students.

Another trend observed in the data is related to the college major interest. Students were asked to circle all college majors that interested them from the following list:

- Engineering (Agricultural / Computer / Electrical / General / Petroleum / etc.)
- Mathematics
- Professional Science (Nursing / Pre-Medical / Pre-Veterinary / etc.)
- Science (Biology / Chemistry / Geology / Physics / etc.)
- Cyber Security (Computer Security / Cryptography / Cyber Security / National Security / etc.)
- Social Science (Criminal Justice / Political Science / Psychology / Sociology / etc.)
- Technology (Computer Science / Information Systems / etc.)
- Other

Those who selected Other were asked to write in the other college majors that interested them. This question was asked on both the pre-survey and the post-survey to see if the program affected interests in college majors.

The six majors which were selected by at least 25% the students on the post-survey were cyber security, technology, engineering, mathematics, science, and other as shown in Figure 4. The most common other majors listed were business, pre-law, and art / music.

As shown in Figure 4, there was a strong increase in interest in cyber security majors among the male participants, with 32% (8 students) indicating interest on the pre-survey and 48% (12 students) indicating interest on the post-survey. Female students on the other hand decreased from 30% (6 students) on the pre-survey to 20% (4 students) on the post-survey.

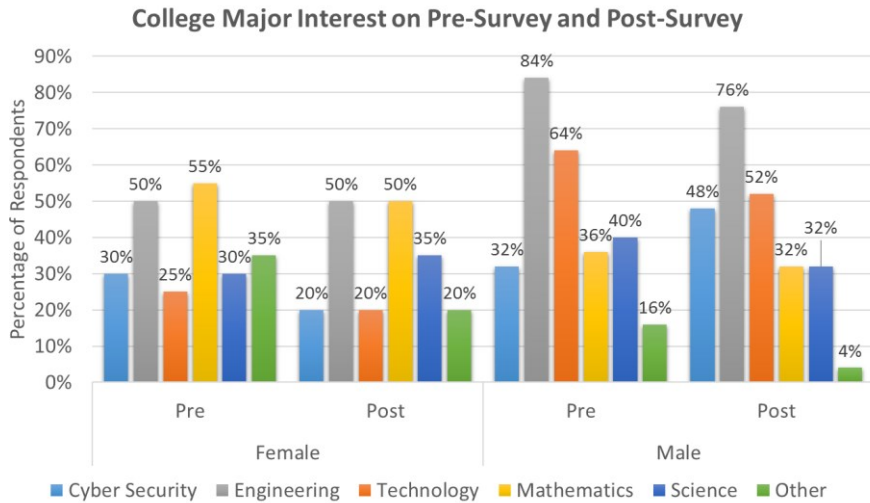


Figure 4: College major interest as indicated in the surveys. Students may select multiple college majors when responding to this question.

Another interesting trend observed was the percentage of students indicating interest in cyber security, technology, and engineering majors. For all three of these majors, male students had a much higher level of interest than female students.

For the technology category, only 25% of female students indicated interest on the pre-survey and that decreased to 20% on the post-survey. Meanwhile, 64% of the male students indicated interest in the technology category on the pre-survey. Male students also had a decrease in interest in technology, with interest going to 52% on the post-survey. Overall though, more than twice as many male students were interested in technology majors such as computer science.

Likewise, for engineering, 50% of the female students indicated interest on the pre-survey, with no decrease on the post-survey. Meanwhile, 84% of the male students indicated interest on the pre-survey. This decreased slightly to 76% on the post-survey.

This leads to a paradox in the survey results. Female students report high levels of satisfaction with the program and have a higher self-reported increased interest

in cyber security as a result of participating in the program. However, the program does not seem to have impacted the planned career trajectory of the female participants. The majority of our participants had already completed their junior or senior year of high school. This outreach program may have been too late to effectively change the mind of students when it comes to college majors and careers.

5.3 Additional Student Tracking

The PI and co-PI monitored participants after completion of the program to see if they attended college and, if so, what major did they declare. Two of the students participated for two summers, leaving 49 unique participants over the three years. The current academic status in Spring 2016 could be determined for 20 (40.8%) of the students: 9 were still attending high school, 10 were attending CSUB, and 1 was attending another university. Most of the participants who are now attending CSUB were in good academic standing.

Of the 11 students who are currently attending college, 5 are computer science majors, 2 are mathematics majors, 2 are engineering majors, and 2 are business majors. Both engineering majors and 4 of the computer science majors are male. The sample size is too small to draw significant conclusions, but this gender ratio is representative of the overall ratio in computer science and engineering instead of the ratio seen in program participants.

6. CONCLUSIONS

The summer program has attracted a diverse group of high school students, both with respects to gender and race/ethnicity, to CSUB to learn about cyber security and cryptography. The program has had a positive impact on the interest in cyber security for a majority of the high school student participants.

However, there is a gender gap in the impact on college major, and therefore the likely career choices, of participants. Male students report lower satisfaction and lower change in general interest in cyber security, but a higher change in interest in pursuing cyber security majors in college. Male students are also more likely to report an interest in cyber security, technology, and engineering majors in college.

And while there was a fairly even split of male and female participants in the program, for the participants currently attending CSUB, the gender ratio follows the national trend for computer science and engineering instead of the demographics of the program.

Since the majority of participants were more than half-way through high school when they attended the program, it is highly probable that the program came too late in their academic careers to have a major impact on students' college plans, particularly for female students.

7. FUTURE WORK

Students in the first cohort were particularly difficult to track with respects to their current academic status. This cohort is the most likely cohort to be in college and progressing on a degree path, since they participated in the program nearly three years ago. Additional efforts will be made to contact participants to determine their current academic status.

Participants who have subsequently enrolled in a degree program at CSUB will be monitored for academic progress to see if the program has a positive impact on success and retention.

Additional cohorts will be hosted at CSUB as time and budget permits. Both the PI and co-PI of the SFS grant have taken on additional administrative responsibilities, which has had a predictable effect on their time to mentor students effectively.

As a result of the dissemination workshop that was part of the SFS grant, the PI and co-PI are in contact with over two dozen regional K-12 teachers who are interested in pursuing additional cyber security activities for their students, as well as additional professional development for themselves. This would provide the best opportunity to reach out to younger students, when a greater impact may be possible on their future college and career plans. Ideas to implement additional outreach programs for younger students are currently on hold due to quarter to

semester calendar changes occurring at CSUB, but will be revisited when that process at CSUB completes.

ACKNOWLEDGEMENTS

Partial support for this work was provided by the National Science Foundation's Federal Cyber Service: Scholarship for Service (SFS) program under Award No. 1241636. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the National Science Foundation.

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