



Cybersecurity, Digital Forensics, and Mobile Computing: Building the Pipeline of Next-generation University Graduates through Focused High School Summer Camps

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Abstract

To prepare the next generation of skilled university graduates that would help in filling the national need for cybersecurity, digital forensics, and mobile computing professionals, a team of minority/under-represented graduate students, the University Upward Bound Program (a federally funded program and part of the U.S. Department of Education; one of 967 programs nationwide) staff, and faculty from the Computer Science (CS) department got together and proposed a focused 10-week long funded summer camp for two local high schools with the following objectives:

1. Provide graduate students to instruct in the areas of mobile application development, forensics and cyber Security.
2. Provide CS one-on-one mentors for students while conducting their work-based learning experience in Computer Science.
3. Assign hands-on interdisciplinary projects that emphasize the importance of STEM fields when using and developing software applications.
4. Promote and develop soft skills among participants including leadership, communications skills, and teamwork.

The proposal was funded, by DOE and the summer camps were conducted in the summer of 2019 with participation of more than 40 students from two local high schools. The paper will present our efforts in each of the above areas:

1. The criteria/application/selection of high school student based on interest and needs.
2. The criteria/specification for purchased equipment
3. The selection and hiring of graduate students as instructors who can not only teach, but also serve as role models for the incoming students.
4. The development of course material into two parts: foundational material required by everyone, and specialized material where the student selects his/her area of interest. Presented results will show how the summer-camps benefited the students through the focused instruction given by graduate students, and how the students gained valuable knowledge and problem-solving skills in certain STEM fields.
5. The mentorship provided by the CS faculty to the instructors and the students through scheduled visits and an agile approach for the software projects assigned.
6. The development of soft skills to complement technical ones

By presenting our study, we hope that other institutions who are considering summer camps can benefit from our experience by adopting best practices while avoiding pitfall.

Keywords

STEM Fields, Cybersecurity, Digital Forensics, and Mobile Computing, High School Summer Camps,

Introduction & Motivation:

There is a national consensus that STEM (science, technology, engineering, and math) related fields are key to the country's continued economic, social, and military success, especially in an ever-changing, global, connected, competitive, and technology-driven world. Therefore, it is imperative that colleges and universities continue their outreach efforts to recruit and expand opportunities in these highly sought after career fields. The growth that STEM related jobs are experiencing is a direct result of the need to renovate the country's physical and electronic infrastructure through traditional and modern fields. With the ever-expanding use of 5G, drones, Big data, cloud computing and IoT, modern database systems, web technologies, social media platforms, AI and Machine Learning algorithms, STEM related jobs are bound to experience continued and steady growth that surpasses other fields.

For the US to continue as a leader in higher education and a haven for scientists and engineers who enjoy innovative high-paying jobs [1-3], it is important to have a diverse workforce, one that has good representation of minority students, economically disadvantaged students, as well as females so that the society as a whole participates and benefits from its young and creative upcoming workforce. Recruitment efforts at universities engage faculty.

Part of every faculty workload is to contribute meaningfully to outreach efforts to recruit students to the college in general and the department in particular. Many of these efforts are usually coordinated with the Office of Student Success at our university, whose mission is "to develop and provide meaningful program experiences that positively impact the college preparation, access, and degree completion of underrepresented students in the region." For the project described in this paper, we have collaborated closely with the Office of Student Success to implement a comprehensive summer camp through their Upward Bound program to promote a steady flow of students through a pipeline into the Computer Science department with emphasis on Forensics and Cybersecurity and Web and Mobile Computing specializations. Unlike short summer camps, this one was comprehensive and had many unique features that we give in detail next.

Before we discuss the summer camp organization, it is worth noting that the department of Computer Science has submitted a proposal for a Bachelor of Science in Cybersecurity to its University Board, and has recruited new faculty to teach the degree new courses when offered. Currently several electives in Forensics and Cybersecurity are offered as upper-level technical electives. However, the department goal is to have a stand-alone degree that follows a holistic approach that integrates technical, legal, business, and policy skills, the proposed program draws on existing courses offered by closely related cybersecurity areas of business, information security, and criminal justice, to make sure that the graduates are well-versed in issues which go well beyond the technical aspect of cybersecurity

Summer Camp Organization

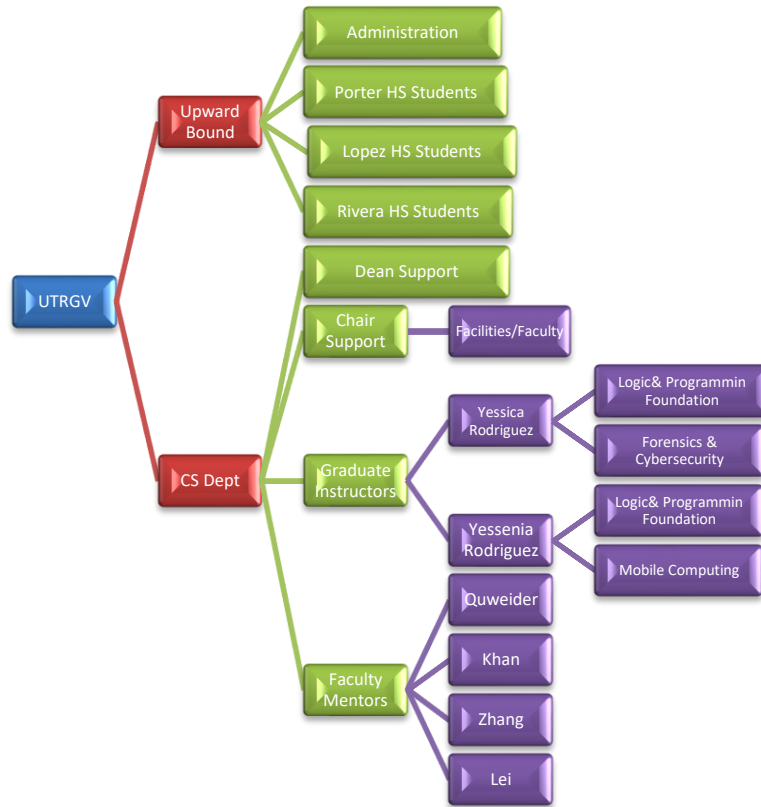


Figure 1. The Organizational Team of the Summer Camp

The summer camp was fully sponsored by Upward Bound, which is “one of eight Federal Programs (TRIO) offering outreach and student services programs designed to identify and provide services for individuals from disadvantaged backgrounds.” Because the program serves high school students from low-income families, and high school students from families in which neither parent holds a bachelor's degree, we elected to conduct a comprehensive summer camp that not only teaches technical concepts, but also provides much needed leadership, team-work, and soft skills. Students for the summer camp were selected from the following Cameron County schools: Lopez Early College High School, Porter Early College High School, Rivera Early College High School.

The arching goal of the camp was to conduct a comprehensive (The equivalent of two university summer sessions), with a short break in between. The first summer session was common to all students and covered basic logic and programming (foundation). During the first session, students were presented sample problems from the specialty areas they had to choose in the second session. The specialty areas selected were Forensics and Cyber Security and Mobile Computing. The two areas were selected due to their importance in creating the next generation of professionals in much needed areas of Computer Science. For example, according to the Bureau of Labor Statistics (BLS), jobs in security and mobile computing related areas enjoy a much faster growth than average. Moreover, the realization of “Critical Shortage” in cybersecurity is being felt in the US, as reported in Chronicle of Higher Education. It was further reported that the cybersecurity job postings grew by 114% from 2011 to 2015, and as a result, many universities including UTRGV have been adding cybersecurity courses/tracks/programs to their curricula.

Application Process

Students from the above schools were asked to fill an application form and provide two references. We were able to recruit a total of 31 students. Table 1. Show the total enrolment with gender distribution. In addition to meeting the program requirements, the application’s reference letters were used to determine what set of non-technical skills the students would benefit from the most. References were asked to rate the student by checking the appropriate response to these statements shown in Fig. 2 with 5- Strongly agree 4- Agree 3- Neither agree/disagree 2- Disagree 1- Strongly disagree

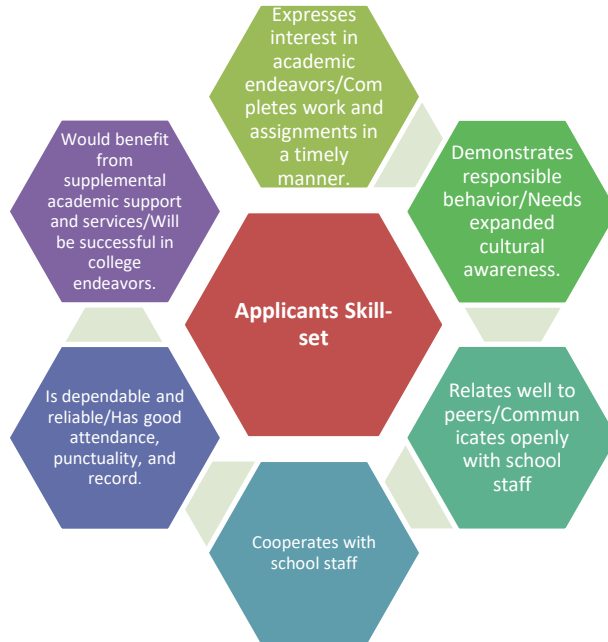


Figure 2. Application Process

Based on the final selection of the students, the CS department team at the university (UTRGV) along with the team from Upward Bound program identified the technical and non-technical skills that were then targeted in the summer camp.

Table 1. Summer Enrollment	
Total	31
Forensics& Cybersecurity Track	16
Mobile Applications Track	15

Gender Gap

As we were planning for the summer camp, one goal of the team, which consisted of two females and two males, was to make sure that the selected applicants are more diverse in terms of the gender, since the schools are already predominantly Hispanics (~98% Hispanics). The gender gap is not new to the STEM, and it has garnered the attention of the research community for many years. In a recent US News article by Gaby Galvin titled “Study: Inclusive Environment Key to Closing STEM Gap,” Gaby points out some stark facts, that are reiterated in other references, that are quoted here verbatim with some emphasis [2],[6-8]:

1. In 1984, **37 percent of computer science majors were women, but by 2014 that number had dropped to 18 percent**, according to a recent study from Accenture and Girls Who Code. To combat the decline, educators must encourage girls to pursue computer science in middle and high school, according to the study.
2. While the number of women in biology, chemistry and math have increased in recent years, the gap has widened in computer science and persists in engineering and physics fields. Echoed by the 2016 U.S. News/Raytheon STEM Index, the research reveals that the **academic culture of these fields is more masculine**, which deters high school girls from enrolling in the often-optional courses.
3. The stereotypical image of a computer scientist, engineer or physicist **doesn't line up with how many girls see themselves or their interests, the report says**. These factors contribute to why women and girls don't feel comfortable in some STEM fields.

Table 2. Summer Enrollment by Gender		
Total	31	
Gender	Females	Males
Forensics& Cybersecurity Track	12	4
Mobile Computing Track	11	4



Figure 3. Summer Camp students and instructors (group picture)

Time & Place

The camp was scheduled over the summer of 2019. The summer camp activities were synchronized with the academic calendar of the University in order to maximize benefits and utilization times during the lecture and lab sessions. Due to comprehensive nature of the camp, the two offered sessions spanned whole summer, with each session lasting for 5 weeks. The two sessions were conducted at the CS facilities, so students could see the actual setting where CS classes and labs are usually conducted. With help from COLTT (Center for On-Line Teaching Technology), all students were given lab/computer credentials. Additionally, every lecture session

had a follow-up lab session so students can integrate theoretical concepts and see how they are applied in real-life situations. Details of the courses are given later.

Technology for students and in the classroom

Every student was given state of the art laptop, an external storage device, and stationary material for the classes. University software as well as open software was also provided for students to complete their assignments, projects, and labs. In class, students could use these laptops and store their work for later use at home or outside the class.

The classrooms where classes were held were provided with multimedia projectors, Wacom tablets, and OneNote software. Additionally, recording software within the course management system was made available for the instructors.

All the necessary materials for the students to succeed in the courses were provided. The students' laptops were provided with the necessary software installed such as NetBeans, Android Studio, and VirtualBox. There were a few occasions that one of the software installed was not done so properly. However, additional material was obtained as needed. For instance, in learning the basics of computer science such as the number system and converting from one form to another, students were constantly in need of a calculator to check their calculations. Thus, the "Student Liaisons," which served as tutors and chaperons for the students submitted a request to the supervisors and graphing calculators were loaned to the students. Furthermore, the VMware Workstation was installed in the computers of the students taking the "Forensic & Digital Cyber Security" course since it was needed for the final project. The students were provided with all the necessary materials to succeed in the courses and assistance when they had trouble with any of the technology required. A student was given a Surface to replace her laptop which had been faulty to ensure she was able to continue with the course. It was essential for students to have a means to access the internet, for the students, like college students, were provided materials and resources through Blackboard, having been given access by UTRGV's IT Services. This gave them the full college experience while having every material necessary available. In addition, students could work and study in designated areas on campus due to a lack of Wi-Fi in some of their homes. These accommodations helped students solely focus on the course and what they were learning.



Figure 4. Summer Camp Teams Presenting Final project

Camp Instructors

While the CS department faculty were available to teach the summer camp, we opted to allow Hispanic graduate students to teach the courses instead, with mentoring and supervision by CS faculty. Doing so has many advantages over faculty teaching including:

Young graduate students (instructors) were more able to connect with the students due to closeness in age and the sharing of many interests

Instructors provided role model for students, especially since they were females and previous graduated from the same school's districts.

Faculty provided course content but allowed the instructors to modify and present according to their taste and preference.



Figure 5. Class Setting for Summer Camp

Mentorship

Four faculty members from the CS department were made available for mentoring for instructors as well as the camp students. Mentors visited the classroom on regular basis and made sure that the sessions were running smoothly. Faculty were present on campus every day, especially with the synchronizing of the camps activities with the University's calendar.

Non-technical Skills

Engineers are notorious for focusing on technical skills and ignoring soft skills that are as important at work and at every level. We saw a great opportunity to make out young students aware of some software skills that they will need as they work in teams at the university level and beyond. Some of these skills include teamwork, communications, interpersonal skills, organization, leadership, volunteerism and civic engagement [5-9].

While some of these skills can be developed in the classroom, we found that real life situations are the best way to hone these skills. As the planning team was approaching faculty to offer mentorship for the instructors and the students, one of the faculty noted that we are running our annual conference and that the students could have the perfect environment to see the importance of the work they were learning as well as develop some of the soft skills that we are trying to instill in them. So, the planning team integrating many activities of the conference into the classroom. Students were able to attend the conference and watch many presentations and poster sessions. Students also volunteered their time in registration, logistics, and to guidance. As the Juana Llanas, director of the Upward Bound program stressed, “Students were engaged in the sessions and were given an opportunity to ask questions and interact with each guest speaker. This provided them with great first-hand experience from a professional conference and career exploration.”



Figure 6. Summer Camp Students at the ICDIS Conference

Technical Skills

As mentioned before, the technical content of the camps consisted of a common session for all students that covered CS logic and basics. This session was conducted over summer-I, and lasted for 5 weeks. The second session was a specialty session, and students were able to choose between Forensics and Cybersecurity or Mobile Application with Web development. The details of the courses are as follows:

Forensic & Cyber Security Team:

This hands-on/project-oriented course and internship examines/explores forensics and cyber security fundamentals, standards of good practice, and basic theory in depth. Topics will include confidentiality, integrity, and authentication techniques. Basic methods and laws of acquiring and analyzing evidence from digital media and computing devices are also covered. Applications will focus on malware, network attacks and defenses, operating systems flaws, and social engineering.

Table 3. Forensics & Cybersecurity Schedule
June 3 – July 9 SSI

UB STEM INTERNSHIP PROGRAM CS LOGIC & BASICS Instructor: Yessica Rodriguez	9-10:20 a.m. Instruction 10:30 -11:15 a.m. Lab	LHSB 1.402 LHSB 1.402
July 11-Aug 16 SSII		
UB STEM INTERNSHIP PROGRAM FORENSIC & CYBER SECURITY Instructor: Yessica Rodriguez	9-10:20 a.m. Instruction 10:30 -11:15 a.m. Lab	LHSB 1.402 LHSB 1.402

Mobile Applications Team

This hands-on/project-oriented course and internship examines the principles of mobile application design and development. Students will learn application development on the Android platform with Java. Topics will include user interface design, data handling with I/O and databases, and network connectivity. Students will conceive, design, implement, and test a project that produces a professional-quality and real-world mobile application.

Table 4. Mobile Applications Schedule		
June 3 – July 9 SSI		
UB STEM INTERNSHIP PROGRAM CS LOGIC & BASICS Instructor: Yessenia Rodriguez	9-10:20 a.m. Instruction 10:30 -11:15 a.m. Lab	LHSB 1.402 LHSB 1.402
July 11-Aug 16 SSII		
UB STEM INTERNSHIP PROGRAM MOBILE APPLICATION + WEB DEVELOPMENT Instructor: Yessenia Rodriguez	9-10:20 a.m. Instruction 10:30 -11:15 a.m. Lab	Set B 1.508 SET B 1.508

Summer Camp Analysis

In analyzing our summer camp, we collected qualitative data related not only to the technical content, but also to the non-technical and soft skill related aspects of the camp. Some of the broad or salient take-aways from the camps include:

The camp raised an awareness among all participants of the importance of a college education in general, and Computer Science in particular.

The camp provided role models to the students as they saw their Hispanic young female instructors excel at what they do. The students were able to connect with the instructors, open and ask technical as well as non-technical questions. With more than half the participants being females, we believe that this was a great decision when planning the camps. The camp allowed the students to appreciate the set of skills needed to successfully pursue a degree in CS. In particular the first summer I session showed the students how important mathematics and problems solving skills are to create meaningful software. The camp emphasized the importance of leadership and teamwork. Students in the specialty session were divided into group and were given a final project to work on as a team as they acquire the necessary skills throughout the session. The team project was in addition to the assignments and individual projects that each student was given.

Students were put in a real-life scenario where they acquired firsthand important job skills that are not technical. From communications, to organization, to customer support, to dress code and etiquette, students started to appreciate the importance of these skills as they participated in the ICDIS conference, helping the attendees.

It remains to be seen how the students will do as they graduate from high school. We plan to trace those students and see how they do in their college career.

Student Feedback

The students were all unsure of what to expect from the course. They had a vague understanding of what computer science was but were unsure what was going to be expected from them. Thus, in the beginning, students were shy and tended not to ask questions. As they progressed in the course, students began to gain confidence. This is where some students' interest in the material was displayed. A group of students inquired about learning a different approach to simplifying Boolean expressions that they had observed was used a lot online when they looked further into it at home. Students' interest was further peaked through the group projects. In the mobile application course, each student group was tasked to design their own mobile application. Within each group, several ideas were discussed, and students were eagerly discussing how they wanted everything to look and work. All the groups had ambitious ideas, and, although they did not all accomplish their goal, they greatly learned and grew to appreciate every application on their phones. One group was greatly discouraged they did not complete their application. This led to a member of the group to research how much time the industry spends developing applications. She included this information in her presentation, stating that she was proud of what she and her group created in a month after learning that it can take several months to develop a mobile application. Eventually, most students seemed to greatly enjoy designing a mobile application or analyzing a virtual device. While computer science was likely not even an option that they were considering, these students are now aware of this field and what it entails, leading them to be more likely to pursue this as a future career.

During their exit interview, students had the chance to voice your opinion and comment on how the summer camp went. The camp evaluations/comments can be summarized as follows:

Most students enjoyed the camp, although they were surprised by the amount of work and details that go into creating a mobile or writing a forensics/security software.

The students unanimously enjoyed the non-technical experiences. They were very proud of the volunteer work they did at the conference

Most students did well in the technical content. Some students felt the work was overwhelming. 24 out of the 30 students earned a passing grade of 70% or above based on total weighted average. Only 3 out of the 30 students were not sure whether they will pursue a career in CS. However, all the participants indicated that they would go to college, regardless of what major they will pursue. All the females indicated that they were glad to see a female instructor conducting the camp.

Conclusions and Future Work

We believe that summer camp was a great success in providing early exposure to the major and trending areas in Computer Science, in the hope of influencing their career choice as they graduate from High school and enroll in a higher education institution.

Unlike short-term summer camps that usually last for one or two weeks, our summer camp simulated a complete summer course as it would be conducted at a university. By doing so, students got to enjoy a real-life example with all its challenges and rewards. As noted in the student feedback, the most common comment was related to how systematic, involved, and intricate you must be to write a fulfilling app or piece of software.

With the help of the Office of Student Success and the Upward Bound program, we plan to follow up with the students to see how they do after high school. In particular, we would like to see the percentage of students who pursue a college degree in general or an Engineering and Computer Science in particular. We would like to know who decided to stay local, and who decided to pursue the degree outside the region.

Acknowledgment

The authors would like to thank Aglhaen Nieto-Cruz and Juana Llana, past and current director of Special Programs—Upward Bound, for their relentless desire in making the summer camp great success and removing any obstacle as the campus was underway. We also extend sincere thanks to COLTT (Center for Online Learning and Teaching Technology) whose staff were instrumental in providing visitor’s computer/lab credentials to all students.

References

1. [HTTPS://phillipscharitable.org/stem-gender-gap-can/](https://phillipscharitable.org/stem-gender-gap-can/)
2. Gaby Galvin, <https://www.usnews.com/news/stem-solutions/articles/2016-11-23/study-girls-less-interested-in-stem-fields-perceived-as-masculine>
3. [WWW.chronicle.com/article/Cybersecurity-Rising/239270](http://www.chronicle.com/article/Cybersecurity-Rising/239270)
4. Bonwell, C., and Eison, J. Active Learning: Creating Excitement in the Classroom. ASHE-ERIC Higher Education Report 1, 1991.
5. ODEP. (2016). Essential skills to getting a job. Retrieved from http://promotions.usa.gov/odep/essential_job_skills.pdf
6. Julia Evetts” Women and careers in engineering: management changes in the work organization,” Women in Management Review Volume 12, Number 6, pp. 228–233, 1997.
7. McRae, S., Devine, F. and Lakey, J., Women into Science and Engineering, Policy Studies Institute, London, 1991.
8. Abrams, L.M., Fentiman, A.W., “An Integrated Program to Recruit and Retain Women Engineering Students,” Proceedings of the 2002 American Society for Engineering Education Annual Conference & Exposition, 1392, 7 pages.
9. Salzman, N., & Delaney, A., & Bates, C. R., & Llewellyn, D. C. (2019, June), Easing Students’ Transitions to University Via a Summer Bridge and Outdoor Experience Program Paper presented at 2019 ASEE Annual Conference & Exposition , Tampa, Florida. <https://peer.asee.org/32685>