

REU Site Program to Engage Undergraduate Students in Cybersecurity Research

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Abstract

This paper presents the establishment of a research experience for undergraduates (REU) site at New York Institute of Technology (NYIT). The objective of the REU site is to train undergraduates to conduct research and also provide participants with professional development opportunities from academia, industry, and government agencies. The major goals of the project are the following: 1) to introduce security research on smartphones and mobile networks to undergraduate students and prepare them for graduate studies; 2) to increase the number of women and minority students from underrepresented groups who engage in security research and provide support for them to become security researchers; 3) to provide research opportunities in a high-demand area to those who would otherwise have no access to research facilities; and 4) to increase awareness of, and approaches to, challenging problems of security in mobile devices and networks. We shared our experience of student recruitment, faculty mentor support, research activity planning and logistics of running an REU site at high living cost metropolitan area. The outcome and success stories of students' accomplishments are outlined in this article.

Introduction

As more smartphones, tablets and other mobile devices are replacing traditional desktops, awareness of security on mobile devices has been raised in both public and private sectors. The demand for researchers and field expertise in security and mobile networks with strong background in Science, Technology, Engineering and Mathematics (STEM) is expected to increase.

In recent years U.S. students' proficiency in STEM disciplines has fallen behind their peers from other countries ^[1-3]. There has been growing concern that the U.S. may not have enough qualified workers in the future to fill positions in the cybersecurity field ^[4]. A report by the Council of Graduate Schools states that first-time enrollment in graduate schools of US students dropped 1.2% in 2010 while first-time enrollment for international students underwent a 4.7% rise compared to the previous year ^[5]. The need for recruiting and retaining students in STEM fields and for training more students to become security researchers and professionals is imminent.

Cybersecurity is a strategic development area at NYIT and the REU program is able to leverage faculty expertise and other resources at the School of Engineering and Computing Sciences. Faculty with expertise in cybersecurity from NYIT School of Engineering and Computing Sciences serve as mentors for the REU program. The school has well established accredited undergraduate and graduate cybersecurity-focused degree offerings. The academic offerings include an undergraduate concentration in Network Security for computer science and information technology majors, as well as an MS program in Information, Network and Computer Security. Faculty experts who taught these courses have been awarded research grants in biometrics, swarm intelligence, cryptography, mobile, and cyber security. NYIT also has received formal validation for various cybersecurity course offerings and certifications from the Committee on National Security Systems (CNSS).

Moreover, the REU team has access to a broad network of industry professionals in the field of

information assurance and cybersecurity, who are invited to talk to the REU fellows. This network includes experts who are involved in joint research with faculty, and have presented at NYIT's Annual Cybersecurity Conference. Every September since 2010, NYIT convenes experts from business, government, and academia to discuss the latest innovations and best practices on topics ranging from active defense and intrusion deception, securing cyber physical devices and the Internet of Things, biometrics and big data analytics as cyber defense tools, the protection of individuals and organizations against cyber-attacks, and research frontiers and cyber education. Many of the local experts are pleased to support the professional development of the next generation of cyber experts.

The objective of the REU site at New York Institute of Technology is to provide opportunities for motivated and talented undergraduate students, with emphasis on women and minority students, to collaborate with NYIT faculty and graduate students on research for methods of securing smartphones on a network and equipment level using both hardware and software designs.

The major goals of the project are: 1) to introduce security research on smartphones and mobile networks to undergraduate students and prepare them for graduate studies; 2) to increase the number of students from underrepresented groups who engage in security research and provide support for them to become security researchers; 3) to provide research opportunities in a high-demand area to those who would otherwise have no access to research facilities; and 4) to increase awareness of, and approaches to, challenging problems of security in mobile devices and networks.

Program Overview

The NYIT REU site was successfully run for three years from April, 2013- March, 2016 under the support of NSF grant CNS-1263283. During this period, the site was very popular among undergraduates and has supported a total of 30 REU fellows. The REU program provided invaluable opportunities for the participating students to apply critical and creative thinking to solve practical engineering problems, realize their career potentials in STEM, gain insights about research, and increase their expertise to be competitive both academically and professionally.

Research Projects

The research projects of the NYIT REU site focused on various aspects of security of mobile devices and wireless networks. Figure 1 shows an overview of the sample projects the REU participants have been engaged in. The projects included: 1) cryptography, 2) user authentication, 3) mobile device medical data collection with privacy, 4) smartphone geolocation, 5) modeling of smartphone botnet, 6) physical capture attack, and 7) wireless network topology. The projects were selected from faculty mentors' research projects and tailored to fit for undergraduate researchers to complete during a 10-week period.



Figure 1. NYIT REU Program Sample Research Projects

The NYIT REU team provided a broad range of research opportunities for the REU fellows over the course of 10 weeks in the summer at NYIT’s New York City campus, where the students have access to a state-of-the art computer lab. Typically, the students selected three choices of their interested research projects in their application. Once the students arrive on campus, they worked with the faculty mentors to identify a particular research topic and outline a research plan. Students were encouraged to collaborate on different aspects of research projects and join forces to tackle a single research project. Upon completion of the research plan, each student then signed a “research contract”, which serves as a general guideline. Every week, students meet with their mentors to discuss progress and obtain detailed guidance on their projects, and they also presented their weekly preliminary results to the REU team and other fellows. This helped them hone in on their presentation skills and receive input on how to deliver certain aspects of their findings.

Student Recruitment

The NYIT REU program primarily targeted rising junior and senior undergraduate students with strong background in mathematics, computer networks, and programming. The project team worked with the NYIT Office of Communications and Marketing, Admissions Office, and Financial Aid Office to carry out the recruitment plan for the REU summer program at NYIT. The team advertised nationally through the NSF REU program website, CRA-W program website, and professional mailing lists. The outreach to women's centers, the Society of Women Engineers, to IEEE Women in Engineering chapters, the National Engineering Society of Black Engineers, and the Society of Hispanic Professional Engineers and to community colleges helped to increase the percentage of women and minority students participating our program.

The NYIT REU site attracted a diverse applicant pool of 276 undergraduate students (29% female, 69% male, 2% no selection or prefer not to specify; 13% African American, 23% Asian, 19% Hispanic/Latino, 3% Native American/American Indian, 46% White, 3% Others) from across the country as well as globally (during the second and the third year of the program, the site hosted undergraduate students from Brazil to collaborate with the REU fellows.)

The team made every effort to provide equal opportunity to access the program for all qualified

applicants. Approximately 67% of the REU fellows were from non-research institutions; 37% of the participants were female undergraduates in STEM majors. More than half of the participants were from underrepresented group or low-income families.

Faculty Mentor Support

The enthusiastic participation of faculty mentors was key to the success of mentoring undergraduate researchers. Undergraduate students are often not exposed to research. Due to the variation in their preparation, some might not have the background for in-depth research. In order to increase awareness of the difference of working with undergraduate researcher and graduate research students, the NYIT REU site offered faculty mentor training prior to the start of the summer program every year. Each year, we invited the Director for Center for Teaching and Learning to share her personal experience as an undergraduate REU fellow and use case studies to provide information on potential scenarios the mentors may face. Faculty mentors also took this opportunity to share their past years' experience of what works best and what does not work so well and the group discussed various approaches and best practices before they embark on a new mentorship commitment. In the end, faculty completed a learning contract as a deliverable of the faculty mentor training session.

Logistics

The success of NYIT REU site relied on the tremendous support from the NYIT community. Faculty and staff from NYIT School of Engineering and Computing Science (main research and mentoring activities), the Industry Advisory Board (site visits), English Department (public speaking and technical writing modules), Library (literature review module), Career Services (Career panel), Grant Office, Payroll, and Administration have all worked together in ensuring the REU students have a rewarding summer research experience. Due to the short duration of the program, logistics sometime could be challenging to ensure participants get paid on time. Therefore, communication among all the supporting offices was key to ensure the timely information distribution and logistics support. Housing for REU students in Manhattan was another challenge the site faced. We were able to find an alternative a few subway stops to our Manhattan campus that provides safe and affordable dorms.

Program Timeline

The program timeline was divided into three stages: 1) Pre-REU Activities, which include program recruitment, logistics preparation, outreach activities, and selection of project participants; 2) REU Activities proper over the course of 10 weeks in the summer, include short summer classes on research, research seminars and workshops (including by external experts from industry or government), student research activities, and social activities, such as tours of research labs and other facilities); and 3) Post-REU Activities including program and project outcome evaluation, REU participants' follow-through, and NSF reporting. Project results dissemination activities included project website updates, students' publications with faculty mentors and presentations of research work at workshops, seminars and conferences.

Program Evaluation and Outcome

The NYIT REU site was evaluated by an outside evaluator via a pre-survey and post-survey for the program at the beginning and in the end of the program. One-on-one "exit" interviews were

also conducted to provide feedback from the REU fellows to improve the program. In addition, after the first year, since 2014, we added a midterm review to provide feedback to the project team to address the concerns from the REU fellows in a timely manner. The REU fellows reported increased confidence and interest in research. Our REU program was able to send four female participants to attend the Grace Hopper Conference in 2013 and 2014. A quote one of our female participants' states: "I feel so lucky to have been a part of the NYIT REU this summer and have had even more opportunities as a result. Thank you all for being wonderful mentors!" Majority of students reported what they enjoyed the most was the hands-on approach to a research problem.

By 2015, fifteen REU participants completed their study at their home institutions. Six of the participants were attending graduate school. One of participants from a non-research institution is currently a Boeing Scholar at Carnegie Mellon University. Two of our female REU participants transferred from non-research institution to STEM research institutions and are planning to pursue graduate studies. A number of our REU fellows have been securing internships in industry to explore different opportunities. During our follow-up communications with our REU fellows, many participants expressed interest in pursuing graduate studies in the future. Our survey showed concerns on finances or acceptance to desired program are mostly reported by students to pursue graduate studies immediately after college.

During the first three years of the program, NYIT REU participants produced 18 technical reports and posters. They also contributed to publications in both peer-reviewed journals ^[6] and conferences. Preliminary findings were presented at the MobileMed 2013 ^[7], IEEE 11th International Conference on Networking, Sensing and Control in 2014 ^[8], Security Communication Networks journal and poster sessions at the NYIT Cybersecurity Conference in 2013 and 2014 and Council of Undergraduate Research REU Scholar Conference in 2013 ^[9-14]. All REU participants attended the ACM WiSec and RFIDSec and volunteered at the conference in 2015. One group of REU researchers was selected to present at the REU Symposium in 2015 ^[15].

Conclusions

This paper outlined the components of the program and shared the experience of recruitment, research mentoring, faculty support as well as logistics of this program and the outcome and success stories of students' accomplishments. Cybersecurity is one of the research areas of importance for national security and is in high demands of talent. Engaging undergraduate students to conduct research in this area will help students to realize their potential on this career path and motivate them to explore research in this critical area. The NYIT REU site was successful at outreaching to a diverse pool of applicants to draw their interest in the program.

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