

## Educating the Next Generation of Cybersecurity Experts

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# Educating the Next Generation of Cybersecurity Experts

## 1.0 Introduction

Cybersecurity is critical to the economy, critical infrastructure, public safety, and national security. Clearly, the demand for cybersecurity experts in the United States is high and continuing to grow. According to *cyberseek.org*, there are currently over 521,600 open positions in the cybersecurity field (including 166,000 Information Security Analyst positions and 355,600 other positions requiring cybersecurity-related skills) across the U.S., with around 1,000 within the state of West Virginia [1]. The Bureau of Labor Statistics has projected that the employment of information security analysts will grow 31% from 2019 to 2029, which is much faster than the average growth of 3.7% for all occupations during that same time period [2]. The current lack of cybersecurity professionals from all demographics is a threat to national security and economic competitiveness [3], [4].

To address this tremendous need for cybersecurity professionals in West Virginia and nationwide, the Lane Department of Computer Science and Electrical Engineering (LCSEE) in the Benjamin M. Statler College of Engineering and Mineral Resources (Statler College) of West Virginia University (WVU) has developed a new B.S. degree in Cybersecurity as well as an Area of Emphasis (AoE) in Cybersecurity for students enrolled in one of the following existing LCSEE majors: Computer Science, Computer Engineering, and Biometric Systems Engineering. Students in any of these majors may also pursue a dual degree with the new B.S. degree in Cybersecurity. The new cybersecurity educational initiatives build on existing strengths and aim to produce work-force ready cybersecurity experts and increase the prospects of enhanced economic development for West Virginia. WVU is designated by the National Security Agency and Department of Homeland Security as a National Center of Academic Excellence in both Cyber Defense Education and Cyber Defense Research [5]. The B.S. degree and AoE in Cybersecurity started to enroll students in fall 2018. As of spring 2019, a total of 19 students were enrolled in a cybersecurity field of study at WVU, including: 4 students pursuing the B.S. degree in Cybersecurity, 6 students pursuing the dual major in Computer Science and Cybersecurity, and 9 students pursuing the AoE in Cybersecurity.

## 2.0 Background

The two-fold goal of the NSF Division of Undergraduate Education (DUE) S-STEM funded *Attracting and Cultivating Cybersecurity Experts and Scholars through Scholarships* (ACCESS) program is: (1) to increase cybersecurity-related STEM degree completion of low-income, high-achieving undergraduate students with demonstrated financial need (including women and minorities) and (2) to generate knowledge about academic success, retention, persistence, graduation, and career pathways of these students to improve the education of future Cybersecurity-related STEM workers. Specifically, ACCESS aims to contribute towards addressing the tremendous governmental and industry need for highly skilled cybersecurity experts by addressing the following four objectives: (1) increasing annual enrollment of students in Computer and Information Sciences B.S. degree programs with specialization in

Cybersecurity; (2) enhancing curricular and extra-curricular support services and activities for students to enhance their educational experiences and build their professional skills; (3) strengthening the partnerships with computer and information technology employers to provide the ACCESS scholarship recipients with a multitude of opportunities to network, learn from, and interact with potential employers; and (4) investigating the impact of the curricular and co-curricular activities on increasing student interest and academic success in the cybersecurity field of study. While significant research has been done relative to student success, retention, and persistence to graduation in STEM fields, Cybersecurity is a new field of study and factors affecting student recruitment, academic success, retention, and persistence to graduation within this field are not known.

The following sections of this paper present work completed during the project's first year relating to: recruitment (objective 1), retention (objectives 2 and 3) and research (objective 4).

### **3.0 Recruitment, Outreach and Selection of Scholarship Students**

Recruitment of students to become future cybersecurity experts is a key focus of the ACCESS program, which will award a total of 120 annual scholarships to 40 unique students over the 5-year period of funding. ACCESS students are recruited from high schools, the WVU Fundamentals of Engineering Program (a common first-year experience in which students complete at least 6 core courses before moving to the major of their choice), and current students who would decide to pursue either a dual major with Cybersecurity or an AoE in Cybersecurity.

The project team engaged in a wide range of recruiting and outreach activities aimed at reaching students, including females and underrepresented minorities, at different academic stages with information about the NSF S-STEM ACCESS scholarship opportunities and inviting students to apply. Separate strategies were implemented to recruit high school students, current and incoming first-year engineering students, and current LCSEE and Statler College students. Furthermore, information about the ACCESS program was shared with the local and state communities and appropriate recruiting materials were developed.

#### **3.1 Recruitment of High School Students**

Recruiting efforts focusing on high school students included making presentations to prospective students and their families at the WVU Statler College *High School Visitation Days* each semester (on-campus for fall 2019 and spring 2020 and virtually for fall 2020) and sending emails to prospective and admitted incoming students for the 2020-2021 and 2021-2022 academic years. Students in the Fundamentals of Engineering Program (FEP) learned about ACCESS through presentations given by project personnel in fall 2019 (in-person) and fall 2020 (recording and live online Q&A), via many direct email messages, and through announcements in the weekly FEP electronic newsletter and the Statler College *ENews*.

#### **3.2 Recruitment of College Students**

A concerted effort was also made to recruit current LCSEE and Statler College students to the ACCESS program. These efforts included: announcing the ACCESS scholarships opportunities in nine large undergraduate computer science and cybersecurity classes (spring and fall 2020);

posting physical flyers on campus (early spring 2020); and creating regular posts in the Statler College *ENews* and in *Fast Lane*, an electronic newsletter for LCSEE students. Information about ACCESS was also sent to student members of WVU chapters of professional organizations, including: CyberWVU, Association for Computing Machinery (ACM), Society of Women Engineers (SWE), Society of Hispanic Professional Engineers (SHPE), National Society of Black Engineers (NSBE) and EngiPRIDE, a WVU LGBTQ+ organization.

ACCESS was also featured in the campus, local, and state communities multiple times. *WVU Today*, a WVU email publication distributed to approximately 30,000 students and 5,000 faculty and staff, published an article in fall 2019, which led to coverage in three additional web-based news sites and a follow-up article in *WVU Magazine* in spring 2020. ACCESS Principle Investigator (PI), Dr. Katerina Goseva-Popstojanova, was interviewed by a local radio station (August 2019) and gave a presentation to about 20 journalists at a 2020 WVU Media Day event and Co-PI, Dr. Brian Woerner, shared the ACCESS scholarship information with over 100 higher education and industry professionals and government officials at the Coding & Cyber Conference in December 2019.

### **3.3 Selection of ACCESS Scholarship Recipients**

Selection of ACCESS scholarship recipients for the 2020-2021 academic year was completed in two rounds. The review of the first round showed that some applications were incomplete and several did not meet the eligibility criteria. The PI team decided to invite students to complete the initially incomplete applications and solicited additional applications. The recruitment efforts yielded 43 applications which were first screened by the college enrollment personnel to evaluate the financial need requirement. Of the 43 applications, 25 candidates met all eligibility requirements. The applicant pool included greater proportions of underrepresented minority groups (16%) and female students (32%) than the pool of students currently enrolled in the Cybersecurity major and AoE at WVU (8% minority and 26% female). The five ACCESS project team members evaluated all 25 applications using a rubric that considered students' GPAs, awards and recognitions, extracurricular and community involvement, essays on cybersecurity, and two recommendation letters. The PI team selected three awardees from the first round and six awardees from the second round. One student changed their major and was replaced by a student from the three-person waitlist. The nine awarded students included four members of ethnic or racial minority groups (44% of cohort) and four women (44% of cohort). These proportions are higher than those currently represented in the Cybersecurity profession in which women represent only 10% [3], [8] and minorities represent 26% [9] of all Cybersecurity professionals. Overall, the recruiting strategies and efforts were successful and resulted in a diverse, high-quality first cohort.

ACCESS scholarship recipients are required to perform outreach activities. Because of the COVID-19 pandemic and associated restrictions, the first cohort of ACCESS students were asked to share the 2021-2022 ACCESS scholarship announcement with their former high school teachers, principal, and vice principal; hometown communities; WVU peers and other friends; and anybody else that may be interested. One student also assisted project personnel by sharing ACCESS information to the WVU chapter of the Society of Women Engineers, a student

organization in which she is an active member. These efforts will contribute to the recruitment of the next cohort of ACCESS scholars.

#### **4.0 Retention and Persistence to Graduation Activities**

Student engagement is essential to academic success and development as cybersecurity professionals. The ACCESS program provides many co-curricular opportunities to enhance students' undergraduate educational experiences and build professional skills by interacting with peers and experienced professionals. ACCESS students are required to meet regularly with their mentors; attend social events and technical and career development seminars; engage in outreach activities and participate in the ACCESS program assessment-related activities. ACCESS students also participate in a subset of the following optional activities: CyberWVU, a cybersecurity-focused student organization; undergraduate research; summer internships; and tours to local and regional companies. They are also encouraged to serve as summer Coding and Cyber camp counselors. Specific opportunities are described below.

#### **4.1 Cohort Building Efforts**

Several activities were employed to promote cohort-building among the ACCESS scholars. An online ACCESS award ceremony was held (September 2020) in which the first-year cohort of ACCESS scholarship recipients were welcomed and congratulated by the college, department, and ACCESS project leadership as well as by associated industry representatives. In addition, the ACCESS project primary investigator (PI) met with the ACCESS students to learn more about their interests, needs, and suggestions for future ACCESS activities. She also created ACCESS Team, a private online group in Microsoft Teams<sup>®</sup>, to support efficient exchange of information, communication, and interaction which is expected to facilitate the development of relationships and a social community despite the current limited in-person interactions due to COVID-19.

#### **4.2 Mentorship Activities**

Opportunities for expert-peer and peer-peer mentorship were provided. Faculty mentors were assigned to the nine ACCESS scholarship recipients in October 2020. ACCESS students were matched with their mentors based on the students' and faculty preferences and interests.

#### **4.3. CyberWVU and Undergraduate Research**

ACCESS students were invited to participate in CyberWVU. CyberWVU members meet regularly, organize cybersecurity training sessions, and participate in cybersecurity competitions. Five of the nine ACCESS students are currently members of CyberWVU.

All ACCESS students were encouraged to get involved in undergraduate research. Four students expressed interest in pursuing undergraduate research, with two students preparing to begin research activities in 2021.

#### **4.4 Engagement and Partnership with Employers**

ACCESS students connected with industry and government professionals, not only during the award ceremony, but through technical and professional seminars and the investigation and

pursuit of internship opportunities. During the online career development panel discussion, “How to get security clearance,” six panelists (WVU alumni with security clearance who work in industry and governmental agencies) shared their experiences with 22 students (including 8 ACCESS students) and five faculty members. Fourteen students, including seven ACCESS students and five faculty, attended the technical seminar “Exploiting Spacecraft” presented by an industry representative from Aerospace Corporation.

Significant efforts were made to connect ACCESS students with internship opportunities. Not only were these opportunities posted in the ACCESS Team group, but ACCESS students were invited to attend a webinar about jobs and employers in the cybersecurity sector hosted by the Cybersecurity Talent Initiative (CTI) and online connections were facilitated for students to talk with representatives from industry and government organizations, such as SAIC, Aerospace Corporation, Gryphon Technologies, Booz Allen Hamilton, Lawrence Livermore National Laboratory, the nonprofit public policy research institution RAND, and WVU Alumni Association. ACCESS students also attended the WVU biannual STEM-focused Career Fair.

## **5.0 Research**

Understanding the impact of these co-curricular activities on student academic success, retention and persistence within the cybersecurity profession is essential to making institutionalization decisions, providing a practical model for other institutions, and supporting future program modification to provide the best possible experience for students. Since cohort 1 students received ACCESS scholarships for the first time in fall 2020, however, data is not yet available. Analysis of measures of student success and persistence, self-efficacy, and motivation within the cybersecurity field will be topics of future papers.

## **6.0 Challenges**

While the restrictions related to the COVID-19 pandemic presented challenges related to recruitment and programming activities, the ACCESS project team quickly adapted to the new reality and organized online meetings, an award ceremony, panels and seminars, and created an online private group to support effective communication and interaction to achieve year 1 project goals. COVID-19 prevented only two planned activities: (1) physical tours to local and regional industry and governmental employers (who are currently working remotely) and (2) the outreach activities associated with the Summer Coding & Cyber camps (which were cancelled for summer 2020). As the public health situation improves in 2021 and beyond, these activities are expected to be completed in person. If the COVID-19 restrictions continue, opportunities for virtual tours to industry and governmental employers will be explored.

## **7.0 Conclusion and Future Work**

Despite the challenges presented by the COVID-19 pandemic and its related restrictions, in year 1 of the ACCESS program, the project team:

- Developed a broad and successful strategy for recruiting students [10] and successfully used it to recruit a first ACCESS cohort of nine students, comprised of 44% underrepresented

minorities and 44% female, which was more diverse than the existing population of students in the cybersecurity major and area of emphasis and in the current cybersecurity workforce.

- Increased enrollment of students with specialization in cybersecurity from 19 students (spring 2019) to 50 students (spring 2020).
- Connected students and professionals from industry and government [10] and provided opportunities for mentorship, training, and professional development.
- Fostered public and professional awareness of the ACCESS program [10].

While the ACCESS program will continue many of the successful activities from its first year, future work centers on improving recruiting materials and expanding outreach efforts as well as collecting, analyzing and reporting data from research into student success, retention, self-efficacy, and motivation within the cybersecurity field. As the COVID-19 pandemic situation permits, the team plans to organize tours to local and regional industry and government employers, increase outreach to K-12 students through summer camps and school visits, and move some of the current online activities to an in-person (or hybrid) format. Most importantly, however, the ACCESS leadership team will continue to foster public and professional awareness of the ACCESS project efforts and opportunities, recruit the new cohort of ACCESS scholarship recipients, and continue to connect students with peers, mentors, and industry and government professionals, providing them opportunities to network, learn from, and interact with potential employers for internships or full-time positions.

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