Board 353: On ACCESS Program Support for Students' Academic Successin the Cybersecurity Field

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On ACCESS Program Support for Students' Academic Success in the Cybersecurity Field

Abstract

The goal of the NSF S-STEM funded program "Attracting and Cultivating Cybersecurity Experts and Scholars through Scholarships" (ACCESS) is to increase the cybersecurity-related degree completion of high-achieving undergraduate students with demonstrated financial need and thus help address the tremendous unmet need for highly skilled cybersecurity experts. The ACCESS program has successfully awarded scholarships to three cohorts of students and has achieved its goal to increase the annual enrollment of students in the B.S. and Area of Emphasis in Cybersecurity at West Virginia University. Specifically, the enrollment has more than doubled in only two years (from 2020 to 2022). Furthermore, the ACCESS scholarship recipients have greater diversity than their peers enrolled in the cybersecurity field at West Virginia University. Over the last three years, the ACCESS program provided numerous co-curricular activities and student support services and has strengthen its partnerships with employers from the public and private sectors. Students' feedback, which was provided via anonymous surveys and focus groups discussions conducted by an external evaluation team, was overwhelmingly positive and highlighted numerous benefits of the ACCESS program to students' education and future professional careers.

1. Introduction

Cybersecurity is of vital importance for protecting individuals, businesses, and government institutions from cyber threats. Furthermore, strong cybersecurity is essential for ensuring uninterrupted work of the critical infrastructure and the national security. However, there is a huge unmet need for cybersecurity experts in the U.S. According to *cyberseek.org*, nationwide there are over 755,700 open positions for different cybersecurity career pathways, which is a significant increase from 597,700 open positions one year ago [1]. The Bureau of Labor Statistics projects that the employment of information security analysts, which is one of the cybersecurity career pathways, will grow 34.7% from 2021 to 2031, which is much higher than the average growth of 5.3% for all occupations during that same time period [2].

To help address this high demand for cybersecurity professionals, a new B.S. in Cybersecurity[1] degree and an Area of Emphasis (AoE) in Cybersecurity[2] for other B.S. majors were developed at West Virginia University (WVU). The B.S. and AoE in Cybersecurity started enrolling students in fall 2018. The B.S. in Cybersecurity is the newest B.S. degree offered by the Lane Department of Computer Science and Electrical Engineering (LCSEE) at WVU. This degree was designed specifically to map to the ABET accreditation criteria for Cybersecurity, Centers of Academic Excellence (CAE) Knowledge Units, and the NIST framework. In 2022 the B.S. in Cybersecurity program at WVU was granted an ABET accreditation for a period of six years and it was redesignated by the National Security Agency (NSA) and a committee of academic peers as a National Center of Academic Excellence in Cyber Defense Education (CAE-CD) through

[1] https://admissions.wvu.edu/academics/majors/cybersecurity

[2] http://catalog.wvu.edu/undergraduate/collegeofengineeringandmineralresources/lanedepartmentofcomputerscienceand/computer_science/#areaofemphasistext

the academic year 2027. WVU is also a National Center of Academic Excellence in Cyber Research (CAE-R). LCSEE faculty are actively conducting research in several cybersecurity areas, such as software security, information assurance, intelligent malware detection, cyber-physical systems security, resilient systems, and application of biometrics identification to cybersecurity.

The NSF Division of Undergraduate Education (DUE) S-STEM funded project "Attracting and Cultivating Cybersecurity Experts and Scholars through Scholarships (ACCESS)" integrates the tremendous need of the private and public sectors for highly skilled cybersecurity experts with the goal to increase the number of students who complete STEM degrees. The ACCESS program aims to achieve the following four objectives: (1) increase the annual enrollment of students in the B.S. and AoE in Cybersecurity at WVU; (2) enhance the co-curricular activities and student support services; (3) strengthen partnerships with employers from the public and private sectors; and (4) investigate the impact of the ACCESS project activities on students' success.

The ACCESS project team carried out a wide range of recruitment activities to reach high school students and current WVU students at different academic stages, with specific focus on increasing the diversity. To date, the project team selected Cohort 1, Cohort 2, and Cohort 3 of scholarship recipients for the school years 2020/21, 2021/22, and 2022/23, respectively. A total of 50 annual scholarships in amount of $5,000 were awarded to 32 unique students. The ACCESS program has achieved its goal to increase the annual enrollment of students in the B.S. and AoE in Cybersecurity at WVU, which has more than doubled in two years (from 50 students US citizens in spring 2020 to 106 students US citizens in spring 2022.) Furthermore, the scholarship recipients have greater diversity than their peers enrolled in the cybersecurity field at WVU. Thus, the scholarship recipients of Cohorts 1, 2, and 3 together had 31% female students and 22% students of color, compared to 23% female students and 15% students of color among the 106 US citizens currently enrolled in the Cybersecurity B.S. and AoE.

Besides awarding scholarships, the ACCSS program provides multiple opportunities for the ACCES scholars to engage with cybersecurity professionals, both within and outside of the institution. Co-curricular activities and support services of the ACCESS program include participation in social events and regular meetings with faculty mentors. Research indicates that substantive faculty-student interactions, both in-class and out-of-class, positively affect students' academic success, personal development, and professional preparation [3]. Furthermore, having an assigned college mentor is shown to be positively related to the probability of persisting in college [4].

ACCESS program also includes optional co-curriculum activities and strongly encourages students to participate in CyberWVU [5] (a student organization focused on cybersecurity) and engage in undergraduate research at WVU and other universities.

Furthermore, the ACCESS project has leveraged the existing and developed new partnerships with cybersecurity employers. Renowned cybersecurity experts from the public and private sectors have offered eleven seminars and panels during five semesters. Extra-curricular career-related seminars and workshops provide students opportunities to "learn purely for the sake of learning" without the stress related to how that learning will be evaluated for a grade [6]. These

professional development experiences help students learn the expectations, work norms, challenges and rewards of the cybersecurity profession [7], and provide opportunities for student questions to clarify expectations, relieve fears, and correct misconceptions. These interactions with cybersecurity professionals motivate and encourage students to continue on their path toward a cybersecurity career. It should be noted that the seminars and panels are open to all WVU students and therefore benefit wider student population and contribute to publicizing the Cybersecurity B.S. degree and AoE.

Another key ACCESS program activity is to work with cybersecurity employers to provide the scholars with internship opportunities. Most ACCESS scholars had either internships and/or paid research positions in summers 2021 and 2022. ACCESS scholars found these opportunities very valuable and felt that they provided important professional experiences. Some of these opportunities also led to longer term professional opportunities for students after graduation.

In general, student participation in profession-related activities helps them to learn more about the profession they are preparing to enter [7], motivates them to keep working toward their academic and professional goals, increases their sense of belonging [8] and institutional inclusion [9], [10], and increases their likelihood of excelling academically and personally and persisting to graduation. Tinto stated that a student's commitment to an academic institution is directly related to student engagement in the institution's academic, social, cultural and professional micro-communities [9],[10]. Student learning and development also has been shown to be proportional to the nature and amount of student involvement (i.e., the amount of physical and psychological energy a student invests) [11]. Hence, students must be meaningfully and actively engaged within the institutional micro-communities to increase their likelihood of excelling academically and personally and persisting to graduation [11].

Another ACCESS program objective is to investigate the impact of the ACCESS activities on students' academic success. To achieve this, students' feedback is collected each spring semester via anonymous survey and focus groups discussions that are conducted by the Evaluation team at the University of Washington Center for Evaluation and Research for STEM Equity. Part of the quantitative and qualitative analyses of the data collected in spring 2022 from Cohort 1 and 2 students are presented in this paper. As evident from the detailed evaluation analysis, students' feedback about the ACCESS program was overwhelmingly positive and highlighted numerous benefits of the program. The dissemination of the ACCESS program experiences and educational research findings [1], [12], [13],[14] supports generating knowledge that could be implemented wider at WVU, as well as in other institutions.

The rest of this paper is organized as follows. Section 2 provides an overview of the recruitment activities, awarded ACCESS scholarships, and the contribution towards increasing the annual enrollment of students in the cybersecurity field at WVU. Section 3 describes the co-curricular activities and student support services provided by the ACCESS program and Section 4 describes the activities aimed at strengthening the ACCESS program partnerships with cybersecurity employers. Both Section 3 and Section 4 include analysis of students' feedback on the corresponding ACCESS program activities. The evaluation of the impact of ACCESS activities on students' success is presented in Section 5, followed by the description of the lessons learned and future plans in Section 6. The concluding remarks are given in Section 7.

2. Awarded ACCESS scholarships and contribution towards increasing the annual enrollment of students in the B.S. and AoE in Cybersecurity

To be able to achieve the first objective, the ACCESS project team carried out a wide range of recruitment activities to reach high school students and current WVU students at different academic stages. To increase the diversity of the applicant pools and subsequently among the recipients of the ACCESS scholarship, the recruitment efforts leveraged different points of contact for students from various identity groups.

For each cohort, the members of the project team and their network distributed the information about the ACCESS scholarship to (i) high school students; (ii) admitted incoming and current freshmen engineering[3] students; and (iii) current LCSEE students who would decide to pursue either dual B.S. major with Cybersecurity or AoE in Cybersecurity. In addition to regular posts in the eNews of the Statler College of Engineering and Mineral Resources (Statler College), the project team also shared the information with students in freshman engineering classes and twelve large undergraduate classes in LCSEE. In order to reach diverse groups of students, the ACCESS scholarship information was shared through various professional societies and clubs at WVU. These included the National Society of Black Engineers, Society of Hispanic Professional Engineers, Society of Women Engineers, ACM, IEEE, CyberWVU, Student Society for the Advancement of Biometrics, EcoCar, and Engineers without Boarders. Additionally, the project team shared the scholarship announcements with ACCESS recipients for snowball distribution. Namely, each year the current ACCESS scholars are asked to share the scholarship information with their WVU friends and peers, high school teachers, principal, vice principal, and counselor, and anyone else that might be interested. The wide range of recruiting outreach activities demonstrate deliberate efforts to leverage different points of contact for students from various identity groups and at different academic stages.

To date, the project team successfully selected three cohorts of scholarship recipients, consisting of 32 unique students, who were awarded a total of 50 annual scholarships in amount of $5,000 each. Table 1 shows the breakdown per cohort of the numbers of ACCESS awards, graduated ACCESS scholars, not renewed scholarships, and current ACCESS scholars. So far, seven ACCESS scholars have graduated, six from Cohort 1 and one from Cohort 2. Of these seven students, four graduated in Spring 2022 and three in Fall 2022. Six of the seven students have started working full time in industry or government sector, and one student enrolled in the M.S. in Computer Science program at WVU. Only five out of 32 ACCESS scholars did not have their scholarships renewed. Each of them did not satisfy at least one of the renewal criteria. One of these students graduated without completing the Cybersecurity AoE due to personal reasons. Three students did not satisfy the minimum GPA requirement of 3.0. One of them graduated with a B.S. in Cybersecurity degree, while two are still pursuing their degrees. The fifth student whose scholarship was not renewed changed his major to a non-STEM major. Currently, there are 20 students in the ACCESS program: 2 from Cohort 1, 5 from Cohort 2, and 13 from Cohort 3.

[3] All freshmen students in Statler College are admitted to the common Fundamentals of Engineering Program (FEP) and must complete at least six core courses before moving to their major.

Table 1. Breakdown per cohort of the numbers of ACCESS awards, graduated ACCESS scholars, not renewed scholarships, and current ACCESS scholars

	Cohort 1 2020/21	Cohort 2 2021/22	Cohort 3 2022/23	Total
ACCESS scholarships awarded	9	10	13	32
Graduated	6	1	0	7
Not renewed	1	4	0	5
Current ACCESS scholars	2	5	13	20

The ACCESS project has successfully accomplished its goal to increase the enrollment of students in the B.S. and AoE in Cybersecurity at WVU. As shown in Figure 1, at the time of proposal submission in spring 2019, there were only 19 students enrolled in the Cybersecurity B.S. and AoE at WVU. Since then, the enrollment has shown a strong increasing trend. Specifically, since the ACCESS project started in January 2020 the enrollment has more than doubled, that is, there were 50, 69, and 106 US citizens (an eligibility criterion) in spring 2020, 2021, and 2022, respectively.

The recruitment strategies described earlier were successful in attracting scholarship applications by students from various identity groups and subsequently led to ACCESS scholarship recipients with greater diversity than their peers enrolled in the cybersecurity field at WVU. Specifically, scholarship recipients of Cohorts 1, 2, and 3 together had 31% female students and 22% students of color, compared to 23% female students and 15% students of color among the 106 US citizens who were enrolled in the Cybersecurity B.S. and AoE in the spring 2022 semester (see Figure 2).

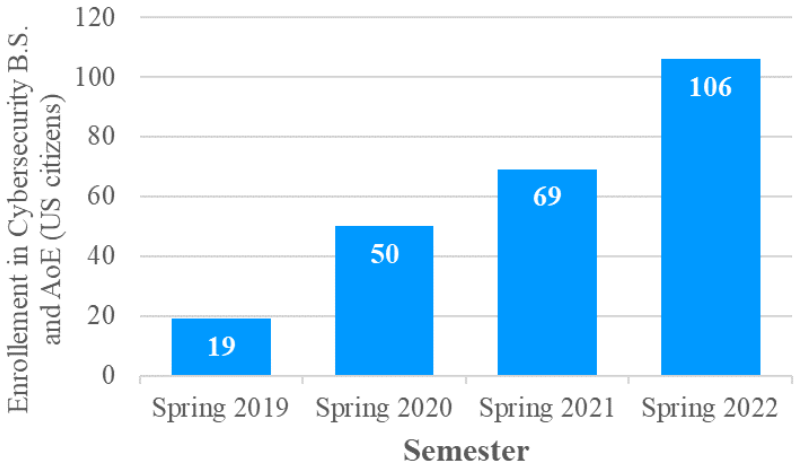

Figure 1. Enrollment in Cybersecurity B.S. degree and AoE at WVU

The effect of the ACCESS program on increasing the diversity of students specializing in Cybersecurity was recognized at the Statler College level. In fall 2022, two ACCESS students participated in “All VOICES as One”, the inaugural student-led diversity conference at Statler College. They presented their poster, “Attracting and Cultivating Cybersecurity Experts and Scholars through Scholarships (ACCESS)” and earned one of the three awards that alumni

judges selected from around 50 posters submitted for the competition from different WVU student groups and organizations.

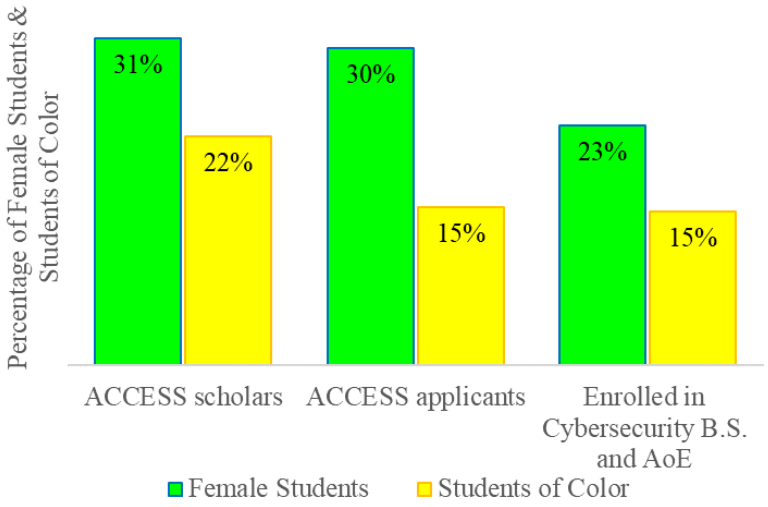

Figure 2. Diversity of ACCESS scholars and applicants of Cohorts 1, 2, and 3 together compared to students (US citizens) enrolled in Cybersecurity B.S. and AoE in Spring 2022

3. Co-curricular activities and student support services provided by the ACCESS program

Besides awarding scholarships, the ACCESS project provides co-curricular activities and support services with a goal to enhance students' education experiences and build their professional and social skills. The activities and services include participating in social events, mentoring, engaging in undergraduate research, and participating in the CyberWVU, which is a student run organization centered on cybersecurity. In this section, we describe these activities and discuss the feedback provided by students depicted in Figure 3.

The ACCESS team organized two types of **social events**: (i) the **Award Ceremonies** that recognized the new scholarship recipients and (ii) the less formal **"Get Together"** meetings to allow exchange of ideas and experiences. Due to the COVID-19 pandemic these events were held online in 2020/21 and 2021/22 academic years, and moved to in-person format in the 2022/23 academic year. As can be seen in Figure 3, some of the surveyed ACCESS students found the Award Ceremonies and Get Together meetings "Very Valuable" or "Somewhat Valuable" while others provided "Neutral" responses, which may reflect, at least in some cases, that these students did not participate in these activities, as well as the fact that due to the COVID-19 restrictions these events were held online.

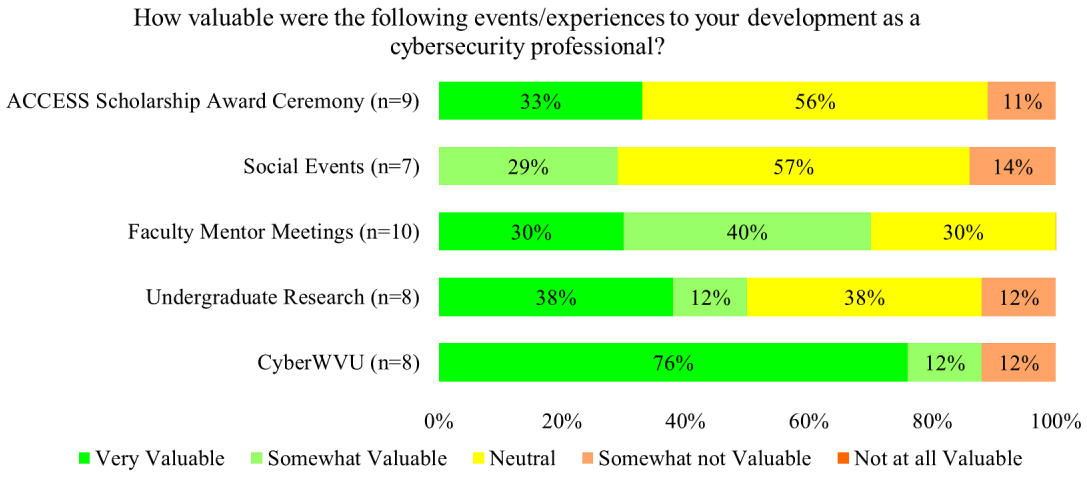

Figure 3. Students' evaluation of the co-curricular activities and support services

Mentors were assigned to ACCESS scholarship recipients based on student and faculty preferences and interests. Seven faculty who teach cybersecurity classes at LCSEE serve as mentors of ACCESS scholars. Each faculty mentors 3 to 4 ACCESS scholars and meets with students at least once each semester. The meetings with ACCESS faculty mentors are in addition to the meetings with students' academic advisors who are aware that students are ACCESS scholars and advise them accordingly to make adequate progress in their education.

A large majority of respondents (70%) found faculty mentor meetings somewhat or very valuable (Figure 3). Several additional survey questions further explored the ways faculty mentors helped ACCESS students. As Figure 4 outlines, all students agreed strongly or somewhat that mentors took them seriously. Most students (90%) agreed somewhat or strongly that mentors provided them support, showed interest in their future, and helped with career advice. 80% of students strongly or somewhat agreed that mentors served as role models.

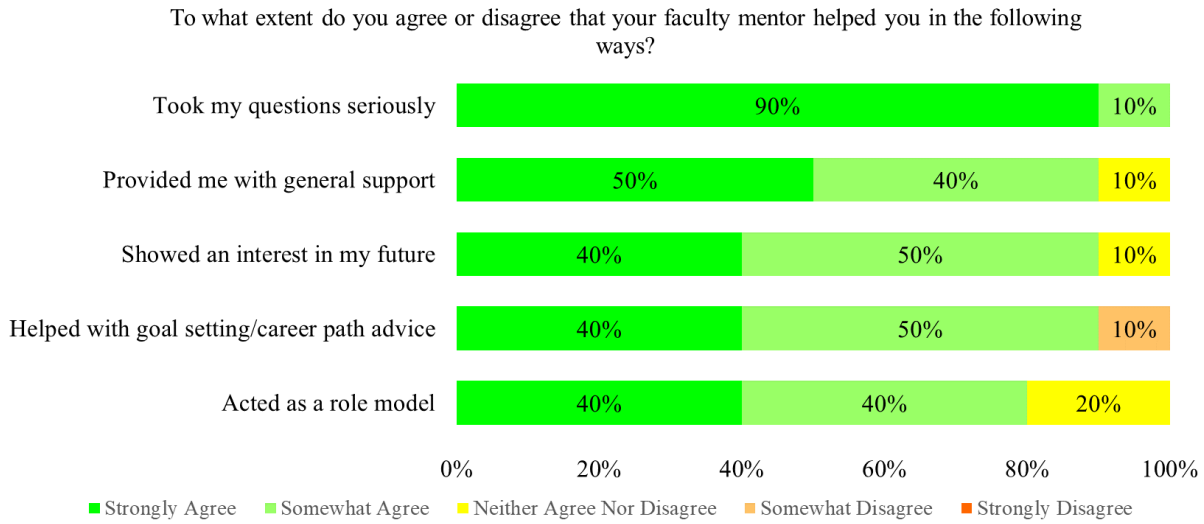

Figure 4. Student evaluation of mentors' support

ACCESS scholars were also made aware of **research opportunities** at WVU and other universities. Over the three years of the ACCESS project, several ACCESS scholars were involved in paid research opportunities by NASA, WVU, Carnegie Mellon University, and Tennessee Tech University. As shown in Figure 3, half of the surveyed ACCESS students found the undergraduate research very valuable or somewhat valuable. Another 38% students provided neutral responses, which at least for some individuals may be due to the fact that they did not participate in undergraduate research as was indicated at the focus group discussions.

Last but not least, ACCESS scholars were encouraged to become members of **CyberWVU**, which is a student organization focused on cybersecurity. Its members meet regularly, organize cybersecurity training sessions and participate in cybersecurity competitions. Fifteen out of 20 current ACCESS scholars are members of CyberWVU.

CyberWVU also stood out as valuable to the majority of students (88%), which was highlighted for how it supports students' technical skills development and the community-building opportunities it provides. One student described their perspective on this as follows:

> "Being able to meet other people that are interested in the same major as you and finding people to do coursework with I think is really helpful. There's a lot of these tough CS projects that take multiple different people to figure out how to do something –what functions to write – so just having people with a similar mindset and different sets of skills, it's really nice to learn and become a better cyber student."

4. ACCESS program partnerships with cybersecurity employers

The ACCESS project has leveraged the existing and developed new partnerships with cybersecurity employers from both private and public sectors.

Renowned cybersecurity experts from the public and private sectors offered **eleven seminars and panels during five semesters** (fall 2020 - fall 2022). The technical topics addressed at seminars and panels included importance of cyber domain in national security, using digital twins for cybersecurity testing, penetration testing, mitigating cyber threats, and generating synthetic data and their implications to cybersecurity. The career development seminars and panels were focused on different career paths within the cybersecurity domain, how to get a security clearance, and how to become a cybersecurity research scientist. It is important to emphasize that the seminars and panels are open to and benefit all WVU students, as well as contribute to publicizing the B.S. and AoE in Cybersecurity in general and the ACCESS program in particular.

A large majority of students (89%) found the seminars valuable, as shown in Figure 5. A popular seminar that students from different focus groups reported enjoying was the ACCESS program's technical seminar on "Hacking and Getting Paid for It - Penetration Testing Discussion, what it is and isn't." Qualitative responses to the survey and focus group input revealed that students very much appreciated the opportunity to connect with professionals and to learn practical information about potential career paths moving forward. One student put it this way:

"I would say that the information access has been the strongest part of this program. I think that there are a lot of subfields or very niche parts of cybersecurity or computer science that people just won't even consider unless they have a knack for it and being able to tune in and see the professional side of these topics that I didn't even know existed has been very interesting and constructive."

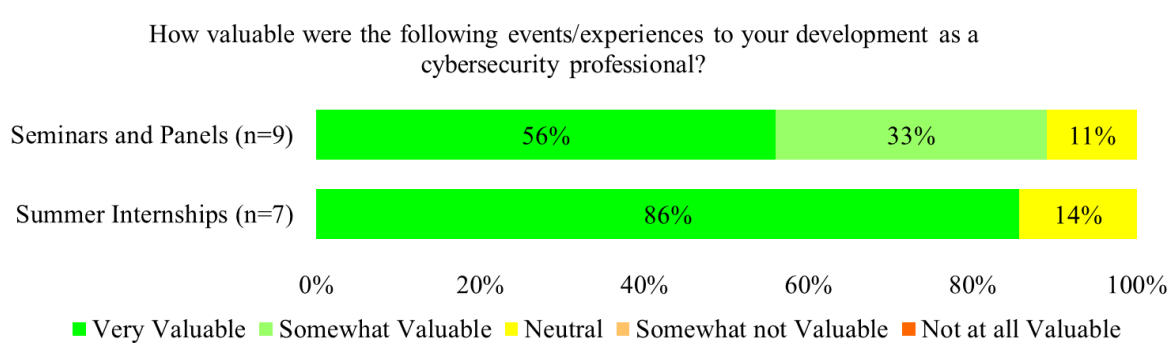

Figure 5. Student evaluation of Seminars/Panels and Summer Internships

The ACCESS project team actively worked with numerous employers to provide the scholars with **internship opportunities**. In summer 2021, eight out of nine Cohort 1 ACCESS scholars had paid internships or research positions. In summer 2022, all four remaining Cohort 1 students and three (out of 7) Cohort 2 ACCESS scholars had paid internships or research positions. The lower number of summer positions for Cohort 2 was likely because four out of seven students were rising sophomores, and there are fewer internship and research opportunities for students who are earlier in their studies.

A large majority of the students (86%) who responded to the item about summer internships reportedly found these opportunities very valuable (see Figure 5). Focus group discussions suggested that these provide important professional experience. As one person put it, "It's cool to get experience, especially to gain more skills that I wouldn't necessarily learn in the classroom." Some of these opportunities are also leading to longer term professional opportunities for students after graduation. By 2023, six Cohort 1 and one Cohort 2 students had graduated and gained paid positions with renowned companies (e.g., Accenture, VMware, MITRE, and WVU Medicine) or enrolled in graduate studies (at WVU).

5. Investigating the impact of ACCESS activities on students' academic success

Another important objective of the ACCESS program is to investigate the impact of the ACCESS activities on students' success and generate knowledge that could be implemented in other institutions.

The information about ACCESS scholars' experiences each academic year was collected in the Spring semesters by two means:

- The annual survey, which was created in collaboration with the Evaluation team from the University of Washington Center for Evaluation and Research for STEM Equity and administered in four classes at different levels.
- Focus groups interviews, which were conducted online by the Evaluation team.

Based on both quantitative and qualitative data collected through surveys and focus groups in spring 2021, the research team published /presented a poster paper at ASEE 2022 [1], posters at AAAS 2021 [12] and AAAS 2022 [13], and a research paper at ASEE 2022 [14].

The analysis of the data collected in spring 2022 from the Cohort 1 and 2 students is presented in this paper. Sections 3 and 4 include analysis of students' feedback on ACCESS co-curricular activities and collaboration with the cybersecurity employers, respectively. This section is focused on evaluation of the benefits from the ACCESS program.

Student feedback from across cohorts was overwhelmingly positive about the ACCESS program, and they particularly highlighted networking and professional skill building opportunities and benefits of the program. An overwhelming majority of students were happy overall with the program. In the 2022 survey, nine (90%) people reported being very likely to recommend the program to others (see Figure 6). One person (10%) reported being only somewhat likely to recommend the program, however, they did not provide any additional written feedback to explain their answer.

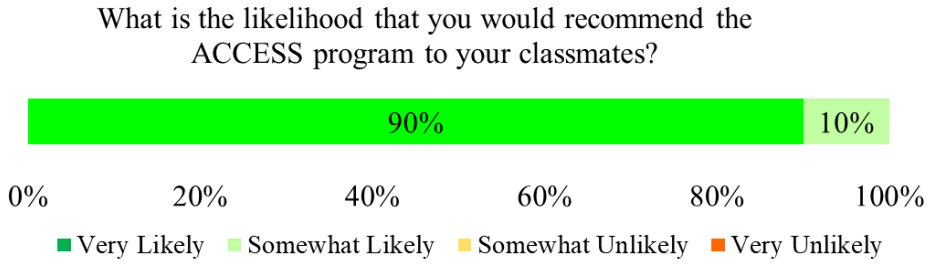

Figure 6. Students' feedback about the ACCESS program overall

Student satisfaction with the program may relate to their reports that they gained substantial benefits from the program. As one student put it, "I can definitely attribute a lot of finding my direction and just generally learning about what all is out there from the program."

As shown in Figure 7, ACCESS students unanimously agreed that they had the opportunity to learn from cybersecurity professionals. Large majorities indicated they are strongly or somewhat more confident starting a cybersecurity career (80%), have learned about career opportunities they would not have otherwise known about (90%), and are able to access resources that will help them in their field (80%). A smaller majority (60%) strongly or somewhat agreed that they have received hands-on experience in cybersecurity and half agreed they have developed relationships with other students in this discipline. The lower levels of agreement in terms of developing relationships with peers may relate challenges with community building online, which students highlighted during focus groups.

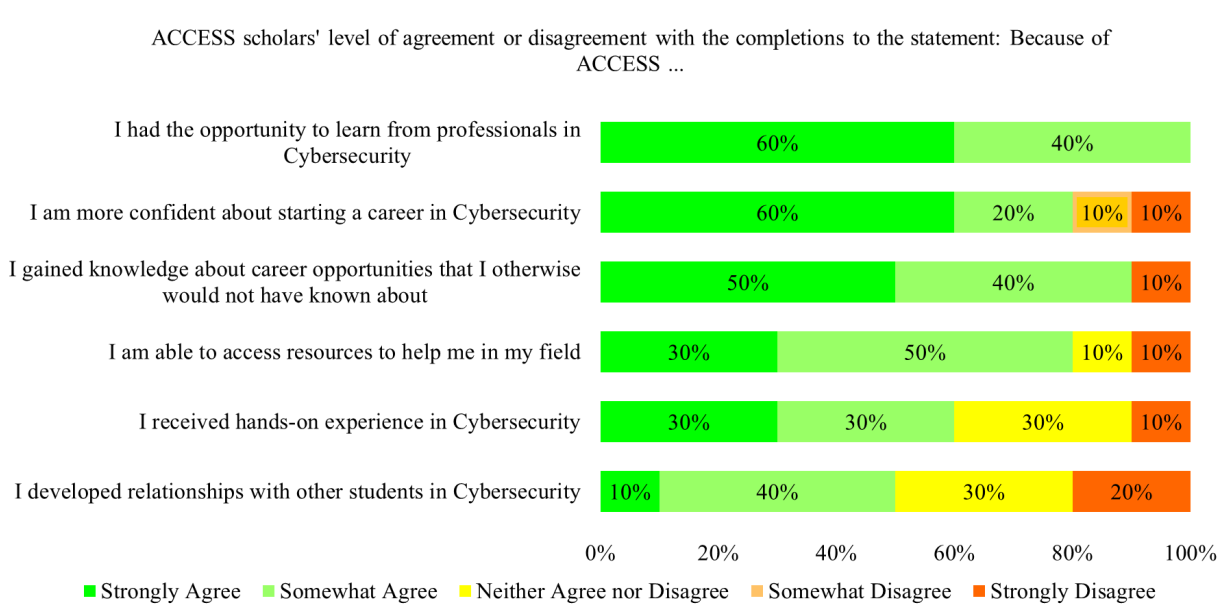

Figure 7. Students' feedback about benefits from the ACCESS program

6. Lessons learned and future plans

In this section we summarize the lessons learned based on the ACCESS team observations and students' feedback, and present our future plans.

As discussed in Sections 3-5, students' feedback about the ACCESS program was overwhelmingly positive and highlighted numerous benefits of the program. In the future, the ACCESS program will continue offering activities valued by the students. For example, **the ACCESS team will continue offering seminars and panels for ACCESS students that will be opened to all WVU students** and thus help further publicizing the B.S. and AoE in Cybersecurity in general and the ACCESS program in particular. **The ACCESS program will continue connecting the ACCESS scholars with cybersecurity professionals from the public and private sectors**, providing them opportunities to network, learn from and interact with potential employers for internships or full-time positions.

Students also provided suggestions for improving some aspects of the program and faculty made relevant observations as well. In subsequent paragraphs, we describe these opportunities for further enhancing the program and our plans for doing so.

Students suggested the community building and communication aspects of the program could be improved, in part since they were somewhat restricted given the online format imposed by the COVID-19 pandemic during the 2020-21 and 2021-22 school years. At focus groups interviews, students expressed wishing there were more in-person opportunities to connect and communicate with peers, staff, and faculty. Despite a clear desire for more connection through in-person

community building, students also recognized a tension in this feedback, noting that online seminars facilitate greater participation among people who are geographically spread out and busy. As the COVID-19 restrictions eased, **the ACCESS program started hosting in-person and hybrid events in fall 2022 and will continue with this moving forward**, since it provides community-building benefits while making it possible for some speakers to attend without traveling great distances.

During focused group interviews, students also expressed interest in having more areas or designated times to connect with other cybersecurity students. Suggestions included having socials (coffee/get togethers) or a designated cybersecurity study area on campus (ACCESS Scholar Study Lounge). Along these lines, **the ACCESS team will further encourage student-to-student interactions and community building** by helping students to implement some of these suggestions.

Students expressed that they would like greater faculty engagement in seminars and other events and that they had not met often with mentors. They again attributed the latter to online activities and, less often, to busy schedules. Some students indicated that they would like to meet faculty mentors more often in-person (including outside of school, perhaps to shadow faculty in a lab) and that it would be nice if their faculty mentors reached out to them more often.The project team requires ACCESS students to meet with their faculty mentor once per semester and in the future will **foster more connection between students and mentors.** For example, the project team might coach students on possible motivations to request a meeting with a mentor, provide tips on what a meeting request could look like and how to proactively request a meeting with a mentor.

7. Conclusion

The ACCESS project has completed three out of its five years. During this time, the project team created and successfully implemented multiple activities that led to achieving the project's objectives. This paper presented a summary of these achievements, as well as the evaluation of the ACCESS program activities based on students' feedback provided via surveys and focus groups discussions. Overall, students' feedback about the ACCESS program was overwhelmingly positive and highlighted numerous benefits of the program. The paper also presented the lessons learned based on the suggestions provided by the ACCESS scholars and the observations made by faculty, which when integrated together led to formulating our future plans.

8. Acknowledgements

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