Board 396: Supporting Students' Success in the Cybersecurity Field: Accomplishments and Lessons Learned by the ACCESS project

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Supporting students' success in the cybersecurity field: Accomplishments and lessons learned by the ACCESS project

Abstract

The NSF S-STEM funded project "Attracting and Cultivating Cybersecurity Experts and Scholars through Scholarships" (ACCESS) has a goal to increase the number of high-achieving undergraduate students with demonstrated financial need who complete a degree in the cybersecurity field. This goal contributes towards addressing the huge unmet need for cybersecurity experts. This paper presents the activities and the accomplishments of the ACCESS project thus far. The ACCESS project has successfully awarded scholarships to four cohorts of students consisting of a total of 50 unique students and has achieved its objective to increase the annual enrollment in the B.S. and Area of Emphasis (AoE) in Cybersecurity at West Virginia University, Morgantown, WV. Specifically, the enrollment has more than doubled since the beginning of the project. Over four years, the ACCESS project developed and offered numerous co-curricular activities and student support services and has strengthened its partnerships with many cybersecurity employers from the public and private sectors. Students' feedback about the ACCESS project, which was provided using surveys and focus groups discussions conducted by the external evaluation team, was overwhelmingly positive and highlighted significant benefits to students' academic success and their future professional careers. This paper also presents the lessons learned that were synthesized using the observations made by the project team and evaluation team, and the feedback provided by the students. These lessons learned can be institutionalized at West Virginia University and elsewhere in higher education to aid students' success in their education and future professional careers in the cybersecurity field.

1. Introduction

Cybersecurity is of crucial importance for protecting the public and private sector companies, as well as individuals from cyber threats and attacks. Even more, cybersecurity is essential for ensuring the uninterrupted work of critical infrastructure, such as emergency services, energy, health, and the financial sector. Strong cybersecurity is also imperative for preventing and eradicating threats to the national security and defense systems. However, there is a lack of cybersecurity experts to meet the huge demand in the U.S. Specifically, according to *cyberseek.org* currently there are over 572,000 job openings for cybersecurity experts [1]. The Bureau of Labor Statistics projected that the employment of information security analysts, which is only one of many cybersecurity career pathways, is expected to grow 34.7% from 2021 to 2031. This is 6.5 times higher growth than the projected average growth of 5.3% for all occupations during the same period [2].

To contribute towards addressing this huge unmet demand for cybersecurity professionals, a new B.S. in Cybersecurity degree [3] and an Area of Emphasis (AoE) in Cybersecurity [4] for other B.S. majors were developed at the Lane Department of Computer Science and Electrical Engineering (LCSEE), Benjamin M. Statler College of Engineering and Mineral Resources (Statler College) at West Virginia University and started enrolling students in fall 2018. The B.S.

in Cybersecurity curriculum was designed 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 West Virginia University was accredited by ABET for a period of six years and it was redesignated by the National Security Agency (NSA) as a National Center of Academic Excellence in Cyber Defense Education (CAE-CD) through the academic year 2027. West Virginia University is also a National Center of Academic Excellence in Cyber Research (CAE-R). LCSEE faculty are conducting active research in multiple cybersecurity areas, such as software security, intelligent malware detection, information assurance, hardware security, resilient systems, critical infrastructure security, and use of biometric systems for cybersecurity.

The NSF S-STEM funded project ACCESS aims to help address the enormous need for cybersecurity experts by increasing the number of undergraduate students with demonstrated financial need (including women and other underrepresented groups) who complete cybersecurity-related degrees. The ACCESS project has the following objectives: (1) increase the annual enrollment of students in the Cybersecurity B.S. major and Area of Emphasis (AoE) at West Virginia University; (2) enhance the co-curricular activities and student support services; (3) strengthen partnerships with employers from the public and private sector; and (4) investigate the impact of the ACCESS project activities on students' success.

To increase the number of students who complete cybersecurity-related degrees and enter the cybersecurity profession, upon successful recruitment students must be retained and supported throughout their education. The STEM educational literature contains many studies relating the importance of student engagement and mentorship on student retention and persistence to graduation.

Multiple engagement opportunities within the professional field of study facilitate the development of a positive professional identity [5], [6] and a sense of belonging within the university and profession [7] which can ultimately lead to improved retention and persistence to graduation [5], [6]. Sense of belonging facilitates motivation [8], [9], enjoyment [9], and happiness [10] as well as academic success and retention [7], [11], [12].

Multiple mentorship models used with a variety of populations have shown the potential for effective mentorship to be a key factor in driving academic and professional success [13], improving retention [14], and preparing students for professional success in populations as diverse as first-year engineering students [14], veterans [15], upper-level undergraduate engineering students [16], and doctoral students and early professionals [13].

The ACCESS project offers opportunities for students to engage with other cybersecurity students, faculty, and professionals to facilitate their development of a positive professional identity and sense of belonging in the field, increase their confidence in their abilities, and motivate them to persist toward graduation and enter the cybersecurity profession [17] - [21]. This paper summarizes the accomplishments and lessons learned by the ACCESS project over four years.

2. Recruitment, awarded scholarships, and contribution towards the increase of the annual enrollment in the cybersecurity B.S. and AoE

To date, 68 annual scholarships have been awarded to 50 unique students from four cohorts. The successful selection of ACCESS scholars resulted from a wide range of recruitment activities that reached out to high school students, admitted incoming and current freshmen engineering students[1], and current West Virginia University students.

The outreach activities for high school students, and incoming and current freshmen engineering students included: in-person presentations in high schools; e-mails to prospective students, admitted students, and freshmen engineering students; in-person presentations for undecided freshman engineering students; and in-person in-class announcements by the instructors of freshman engineering classes.

The current LCSEE and Statler College students were reached by regular posts in the Statler College eNews and by in-person announcements in large Computer Science, Computer Engineering, and Cybersecurity classes. More targeted advertising was done by reaching out to different student organizations at West Virginia University, which included but were not limited to the Artificial Intelligence Club, Alpha Omega Epsilon, IEEE student chapter, Eta KappaNu, ACM Student Chapter, Amateur Radio Club, Student Society for the Advancement of Biometrics, CyberWVU, Society of Women Engineers, Women in Cybersecurity (WiCyS), Society of Hispanic Professional Engineers, and National Society of Black Engineers.

Outreach was also done by the current ACCESS scholarship recipients, who were asked to share the scholarship announcement with their high school teachers, principal, and vice principal; hometown communities; West Virginia University peers and other friends; and anybody else who may be interested. Additionally, faculty and students were asked to further snowball the call for ACCESS scholarship applications as wide as possible. Finally, the PI, co-PIs, and Department Chair regularly responded to individual inquiries.

Thus far, the ACCESS team successfully selected four cohorts of scholarship recipients. Overall, 50 unique students were awarded a total of 68 annual scholarships in the amount of $5,000 each. The breakdown per cohort of the numbers of ACCESS scholarships awarded, graduated ACCESS scholars, not renewed scholarships, and current ACCESS scholars are shown in Table 1.

The cohorts' sizes had consistently increased over the four years, from 9 scholars in Year 1 to 10, 13, and 18 scholars in Years 2, 3, and 4, respectively. Thus, Cohort 4 represents the largest group of students since the project began and is double the size of Cohort 1. The increasing size of the Cohorts is due to ACCESS scholars' graduating faster than initially planned, which opened additional funds for scholarships.

[1] All freshmen students in the 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. Some of these students have not decided which Statler College major they will pursue.

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

	Cohort 1 2020/21	Cohort 2 2021/22	Cohort 3 2022/23	Cohort 4 2023/24	Total
ACCESS scholarships awarded	9	10	13	18	50
Graduated	8	1	1	1	11
Not renewed	1	4	1	0	6
Current ACCESS scholars	0	5	11	17	33

So far, 11 ACCESS scholars have graduated and obtained full-time positions or enrolled in graduate studies. Furthermore, 88% of ACCESS scholars (i.e., 44 out of 50) had their annual scholarships renewed. Out of 6 students who did not have their scholarships renewed, only one changed their major to a non-STEM major. The other five students either graduated or are still pursuing their degrees but did not satisfy at least one of the renewal criteria (e.g., the minimum GPA requirement). Currently, there are 33 students in the ACCESS program: 5 from Cohort 2, 11 from Cohort 3, and 17 from Cohort 3.

Over the four cohorts together, both the ACCESS scholarship recipients and applicants had greater gender diversity than their peers enrolled in the cybersecurity field at West Virginia University. Thus, as can be seen in Figure 1 scholarship recipients of Cohorts 1 - 4 together had 22.0% female students compared to 18.7% among their peers (i.e., West Virginia University students, U.S. citizens enrolled in the cybersecurity field in Spring 2023). On the other side, the percentage of ACCESS scholars of color was slightly lower than among West Virginia University students U.S. citizens enrolled in the cybersecurity field in Spring 2023 (i.e., 18.0% compared to 20.6%).

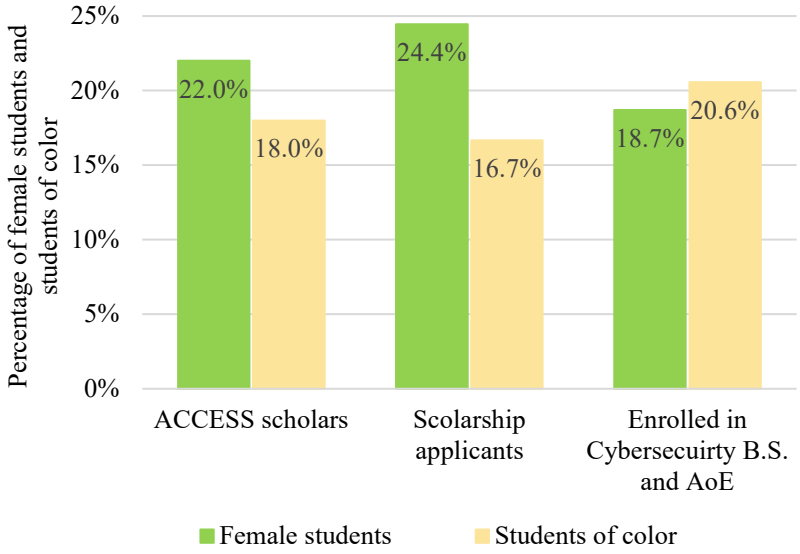

Figure 1. Diversity of ACCESS scholars and applicants of Cohorts 1 - 4 together, compared to West Virginia University students (US citizens) enrolled in the Cybersecurity B.S. and AoE in Spring 2023

Overall, compared to previous years [18],[19] the gender and racial diversity of the eligible applicants and ACCESS scholars decreased despite the wide range of outreach efforts, some of which specifically targeted underrepresented groups of students. The decline in diversity, especially compared to Cohort 1, may partially be due to the fact that many current West Virginia University students from underrepresented groups, who were eligible for the ACCESS scholarship, applied and were selected in the earlier years of the ACCESS project. In addition, decreased diversity may be reflecting the broader trends in college enrollment, broader gender and racial disparities in Computer Science and Cybersecurity, and possibly enduring effects of the COVID-19 pandemic.

The ACCESS team, over time, has increased the outreach activities to high school students. In addition to the outreach done by the ACCESS scholars, by e-mail targeting the incoming freshmen, and outreach activities by the Statler College and LCSEE, after the COVID-19 pandemic the ACCESS team organized numerous in-person visits to regional high schools. These efforts resulted in an increased number of applications from high school students (from 12.0% in 2020 to 41.7% in 2023), which led to an increased number of ACCESS scholarship awards to incoming freshmen (from 0% in 2020 to 50% in 2023). On average, over the four years of the ACCESS project, 27.8% of the applications were from high school students and 36.0% of the ACCESS scholars were incoming freshmen.

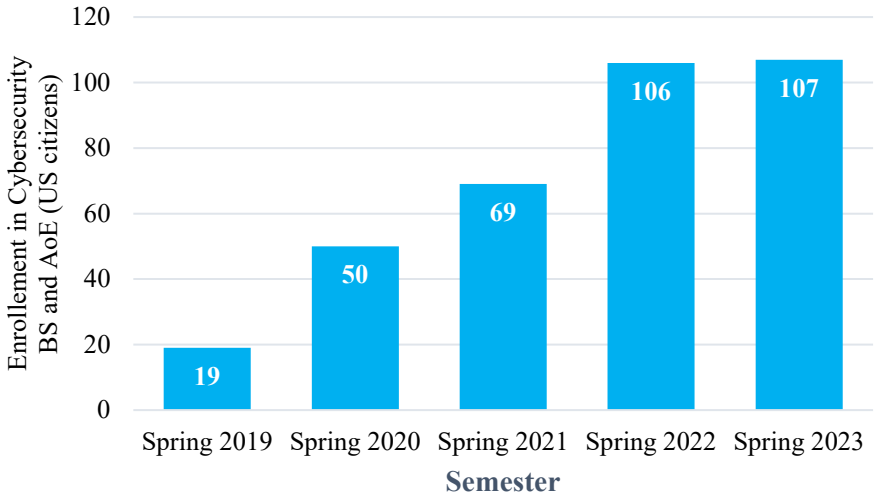

Figure 2. Enrollment in Cybersecurity B.S. degree and AoE at West Virginia University

Overall, the ACCESS project has achieved its objective to increase the Cybersecurity B.S. and AoE enrollment - from 19 student US citizens enrolled at the time of the proposal submission in spring 2019 to 107 student US citizens in spring 2023 (see Figure 2). Specifically, since the ACCESS project started in January 2020 the enrollment has more than doubled, from 50 student U.S. citizens to over 100 student U.S. citizens in spring 2022 and 2023. This strong increasing trend of enrollment is even more impressive keeping in mind that the timeline includes the COVID-19 pandemic.

3. Co-curricular activities and student support services

In addition to the recruitment success, students must be retained to ultimately increase the number of new professionals entering the cybersecurity profession. To increase the retention and degree completion among cybersecurity students, the ACCESS project developed and offered co-curricular activities and support services that aided students' academic and professional success. These included **social events**, such as the **Award Ceremony** held each fall semester and the less formal **Get Together meetings** held each semester. These events were held online in the 2020/21 and 2021/22 academic years due to the COVID-19 pandemic and moved to an in-person format in the 2022/23 academic year. As can be seen in Figure 3, which presents students' evaluation of the co-curricular activities and support services, in Year 4 the ACCESS scholars placed great value in the social events (i.e., 72.8% reported that the award ceremony was very valuable or somewhat valuable, and 90.9% reported that the Get Together social events were very or somewhat valuable). In focus groups, students reported that the social events helped them develop closer relationships with other cybersecurity students, making them feel part of a tighter knit community that they can rely on both socially and academically. For example, one student reported:

> "I'm typically more of an introverted type of person. So, I see the same people…but I don't really connect with them in those [large] classes. But when I see them in [those] classes, and then in ACCESS activities, it's a deeper connection, and I feel like it can actually talk to them…"

Students also indicated that the ACCESS project made it "easier to get to know people" in cybersecurity. Scholars also discussed being able to rely on fellow scholars academically, with one scholar saying: "it's cool to see people that I know and know that if I need help on anything, I have their information to reach out to them."

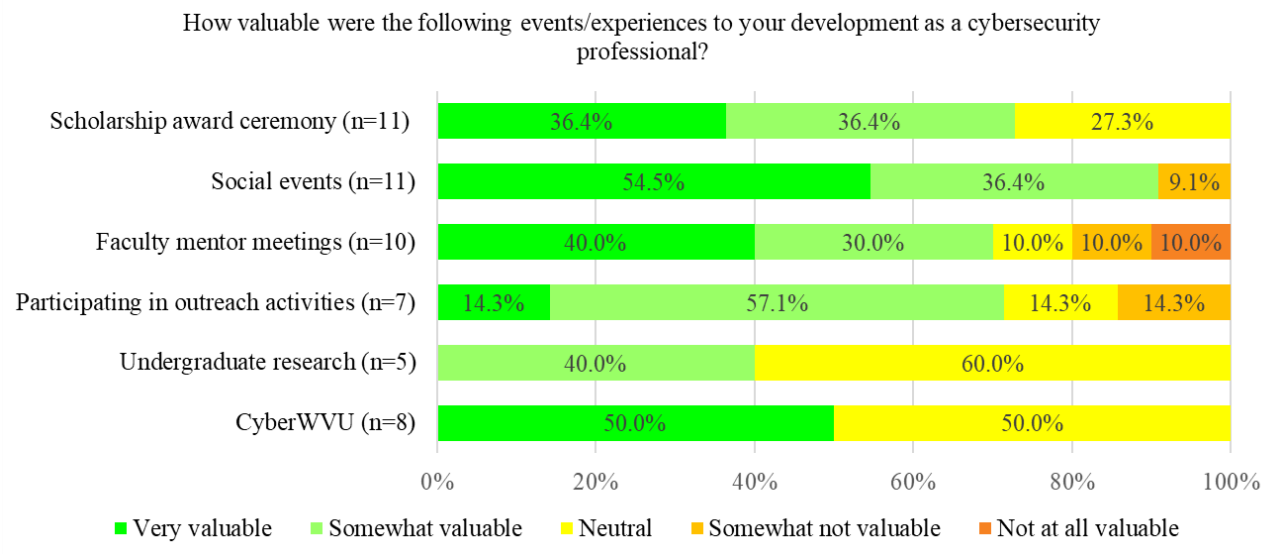

Figure 3. Students' evaluation of the co-curricular activities and support services

ACCESS scholarship recipients were assigned **mentors** based on theirs and faculty preferences and interests. Seven faculty who teach cybersecurity classes at the LCSEE served as mentors of ACCESS scholars. Each faculty mentors 4 to 5 ACCESS scholars and meets with students at least once each semester. In addition to faculty mentors, ACCESS scholars have traditional academic advisors who advise them on how to make adequate progress in their studies and meet the ACCESS requirement of completing B.S. or AoE in Cybersecurity. In Year 4, 70.0% of ACCESS scholars found the meetings with their faculty mentors to be very or somewhat valuable, as shown in Figure 3. Specifically, students felt that meetings were beneficial, helping them discover new opportunities such as undergraduate research programs and discussing post-graduation options. For example, in the focus groups one student reported that their mentor had been "super helpful [to] gauging where I might what to go" and another saying, "it was nice just to…talk about what I plan for my future." Students whose mentors were also their professors described forming deeper connections with them inside and outside of class, with one stating that "it was massively helpful to be able to establish a direct connection with them and be able to like contact him."

ACCESS scholars' responses on several additional questions related to the ways faculty mentors helped them are shown in Figure 4. 90.9% of students strongly or somewhat agreed that mentors took their questions seriously. A large majority of students strongly or somewhat agreed that mentors provided them support (72.8%), showed interest in their future (81.8%), and helped with career advice (81.9%). A smaller percentage of students (63.7%) strongly or somewhat agreed that mentors served as role models. One student strongly disagreed with all survey items related to mentor support and indicated in an open-ended survey response that their "mentor only met with [them] for 10 minutes one time." While the majority of students reported that their experiences with their mentors were valuable, it is important to acknowledge that mentorship programs in various educational settings face challenges. Research has suggested that mentorship programs often encounter difficulties in aligning faculty and student expectations, and ensuring faculty availability/engagement, with studies pointing to institutional barriers that hinder faculty mentorship [22]. For example, within professional academic culture, mentoring relationships are diminished in importance in comparison with other responsibilities within the promotion/tenure process [23].

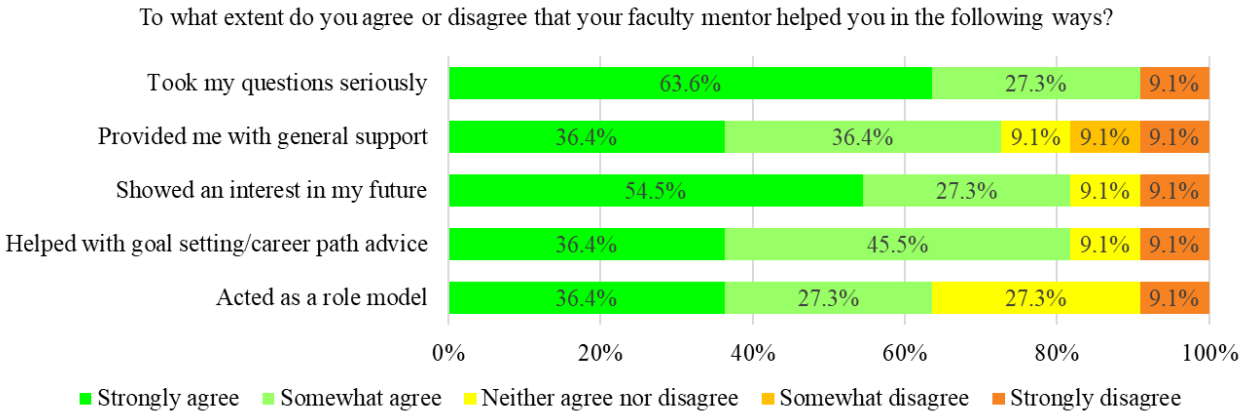

Figure 4. Student evaluation of mentors' support (n=11 respondents)

As described in Section 2, ACCESS's **outreach activities** engaged the current ACCESS scholars. Of the seven students who responded to this question, as can be seen in Figure 3, 71.4% felt that the outreach experiences were very or somewhat valuable.

ACCESS scholars were made aware of **undergraduate research** opportunities at West Virginia University and other universities. Over the four years of the ACCESS project, scholarship recipients were involved in paid research opportunities not only at West Virginia University, but also at NASA; Carnegie Mellon University, Pittsburgh, PA; Tennessee Tech University, Cookeville, TN; and Indraprastha Institute of Information Technology, Delhi, India. As shown in Figure 3, 40% of students who responded to this question found the undergraduate research somewhat valuable while 60% provided neutral responses. Students who participated in undergraduate research opportunities found them extremely valuable to their academic and professional development.

ACCESS scholars were also encouraged to become members of **CyberWVU**, which is a student organization centered on cybersecurity whose members meet regularly, organize training sessions, and participate in cybersecurity competitions. In spring 2023, 14 out of 20 ACCESS scholars (i.e., 70%) were members of the CyberWVU. Half of the students who responded to the question related to CyberWVU found the experience very valuable and the other half were neutral (see Figure 3).

It should be noted that participating in **undergraduate research and CyberWVU** are optional activities which explains the smaller number of respondents (5 and 8, respectively) to the corresponding survey questions. The higher percentage of neutral responses for these two activities, at least for some individuals, may be due to the fact that they did not participate in these activities, but "non-participation" was not one of the available response options in the survey.

4. ACCESS partnerships with employers from the public and private sector

Over the four years, the ACCESS team has deepened the existing partnerships and has established new partnerships with numerous cybersecurity employers. That allowed the ACCESS project to connect the students with professionals from the private and public sectors, providing them with opportunities to network, learn from, and interact with potential employers.

During seven semesters, the ACCESS project has organized 16 seminars and panels which were offered by prominent cybersecurity experts. The technical topics addressed at seminars and panels included the importance of the cyber domain in national security, the impact of ChatGPT on software development and cybersecurity, penetration testing, using digital twins for cybersecurity testing, mitigating cyber threats, and generating synthetic data and their implications to cybersecurity. The career development seminars and panels were focused on how to get a security clearance, different cybersecurity career paths, and how to become a cybersecurity research scientist. Furthermore, many seminar presenters and panel participants shared information about internships and employment opportunities and actively recruited students for those positions. In addition to 16 seminars and panels, over four years ACCESS

scholars were invited to attend numerous events organized by SecureWVU, Statler College, College of Business and Economics, and other entities from academia, government, and industry.

As can be seen in Figure 5, 81.8% of ACCESS scholars in Year 4 found the seminars and panels to be very or somewhat valuable. Seminars and panels have been consistently one of the most appreciated ACCESS activities, with 89% and 100% of respondents rating it as very or somewhat valuable in 2022 and 2021 surveys, respectively. Qualitative responses to the survey and focus group data revealed that students very much appreciated the opportunity to meet and connect with professionals that they otherwise would not without ACCESS project and learn practical information about their future professional careers. One student stated that "if I wanted a job at one of these companies, I would have no problem sending them an email because they were like super like open and welcoming to us." Another student put it this way: "I thought the job market was very narrow and all these different people who have [come] to talk … made me see how broad the opportunities are." Other students reported that the seminars were "eye opening" and "really opened [them] up to different fields of cyber security." Students also appreciated the applied nature of the seminars, with one student stating, "the seminars give more of a clue on how like a real world cyber security application is rather than courses", and another, "They're the people that are coming to tell us this how it really is. This is my experiences, this is how I got here and stuff like that, so they're giving us like an authentic view of their job rather than that pretty painted picture that the Career fair people do."

It is important to emphasize that the seminars and panels were open to and benefited all West Virginia University students. These events also contributed to publicizing the ACCESS program in particular and the B.S. and AoE in Cybersecurity in general.

In addition to networking at other events, the ACCESS team actively worked with numerous employers to provide ACCESS scholars with specific **internship** opportunities, which is one of the optional ACCESS activities. In summer 2023, eleven out of 18 active ACCESS scholars (i.e., 61%) had summer internship positions, both at private (e.g., NetCentrics, 84 Lumber, Parraid LLC., NAWCAD, Patuxent River, Trilogy Innovations) and public sector (e.g., NIST, U.S. Senate, FBI, Civil Military Innovation Institute). Most of the students who did not have internship positions were rising sophomores, for whom there are fewer internship opportunities. Since summer internship is an optional ACCESS activity, similar to undergraduate research and CyberWVU, a smaller number of students (i.e., 6) responded to the corresponding question with one-third finding the experience very valuable while the rest were neutral (see Figure 5). The higher percentage of neutral responses may be due to the lack of a "non-participation" response option in the survey. In focus groups, students who did participate suggested that their internship experiences were high impact and helped shape their career aspirations, with one saying, "After that [seminar] I ended up applying for a cybersecurity internship and now I'm rolling that into a full-time job, so it definitely helped pave that career path."

In general, students have enjoyed connecting and networking with their ACCESS community of student peers, mentors, guest speakers, and other staff. Discussing their relationships with peers, one participant reported, "it's just nice to know that you have this group of people." A female participant expressed being more comfortable approaching her female peers in class as part of a

smaller community: "…seeing the girls in my class, and then going to a seminar, I'm like 'oh, wait! We're in class together.' And then we just kind of connect on that level."

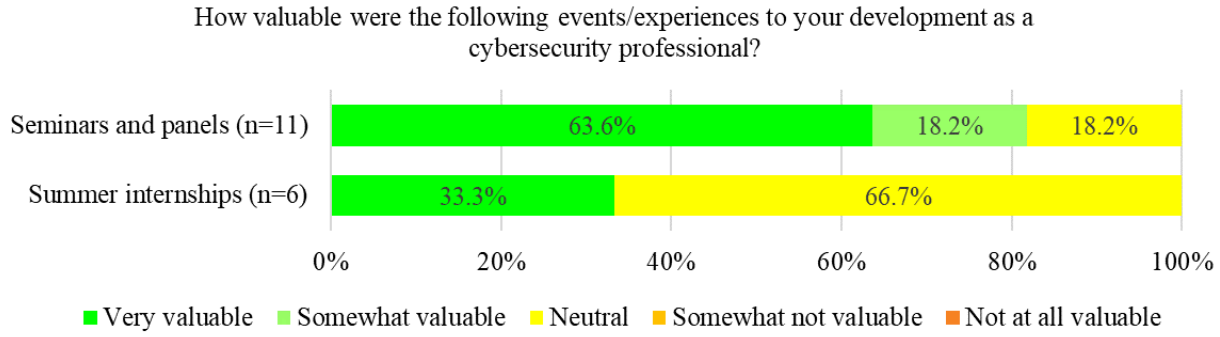

Figure 5. Student evaluation of Seminars/Panels and Summer Internships

5. Investigating the impact of ACCESS activities on students' academic success, professional identity, and sense of belonging

Last but also important, the ACCESS research and evaluation teams collaborate closely on exploring the impact of the ACCESS activities on students' academic success, professional identity, and sense of belonging. Each year, the information about ACCESS scholars' experiences was collected in the spring semester by two means:

- The annual survey, created in collaboration with the external evaluation team from the University of Wahington, Seattle, WA, was administered in four classes at different levels. Eleven (out of 20) ACCESS scholars and over 200 other students in these classes completed the survey in spring 2023.

- Focus group interviews were conducted by the external evaluation team. In spring 2023 there were three focus groups with a total of twelve scholars participating (out of 20 active scholars at that time).

The external evaluators reviewed the project documents, examined student feedback provided in focus groups and survey data, and interviewed the project leaders. The annual evaluation report was included with the annual NSF project report.

The dissemination of the findings so far included publications and poster presentations at ASEE 2021, 2022, and 2023 conferences [17] - [21], AAAS 2021 and 2022 symposia [24], [25] and a seminar given at the University of Maryland College Park [26]. Detailed analysis of the most recently collected data is currently underway and will be presented elsewhere.

Student feedback about ACCESS activities was overwhelmingly positive. As shown in Figure 6, in Year 4, all ACCESS scholars strongly or somewhat agreed that they had the opportunity to learn from cybersecurity professionals and 81.8% were more confident about starting a career in cybersecurity. As one scholar has stated "…when the professionals come in and talk about some of the stuff that they do, and I understand and or have done some of the stuff that they've done,

it's just like ‘oh, wow!’ I thought I am an undergrad student. It just makes me feel like I'm getting smarter and actually like learning stuff.” Furthermore, a large majority of students strongly or somewhat agreed that they learned about career opportunities they would not have otherwise known about (81.8%) and were able to access resources that will help them in their field (81.9%). A smaller majority strongly or somewhat agreed that they have received hands-on experience in cybersecurity (63.7%) and that they have developed relationships with other students in the cybersecurity discipline (63.7%). The latter experienced an increase compared to 50% reported for Year 3 [19], which is likely due to the transitioning of the ACCESS activities from online to fully in-person. The students' feedback for the other statements in Figure 6 was consistent with those reported for Year 3 [19].

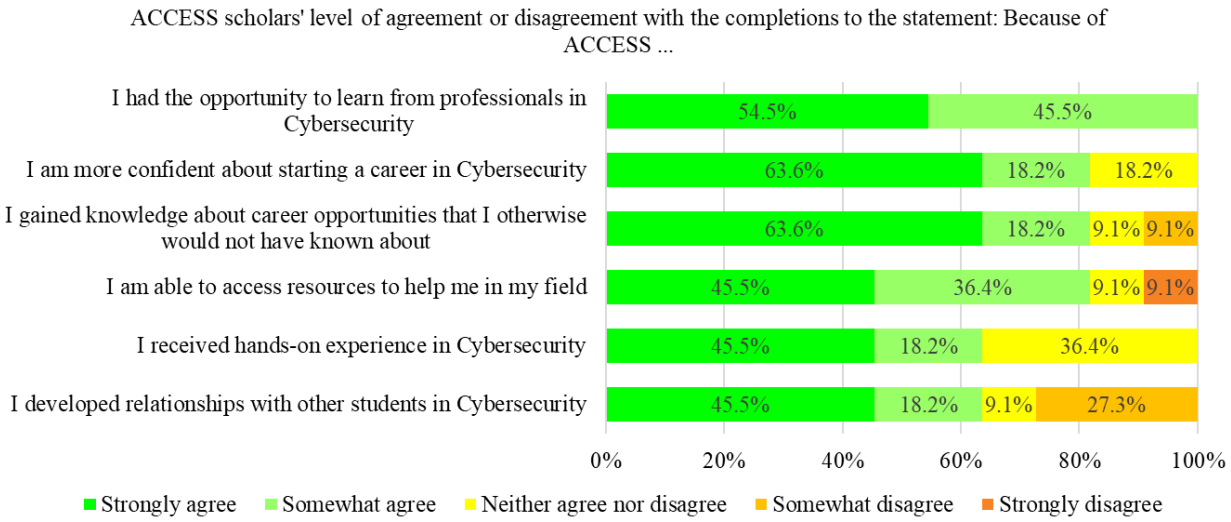

Figure 6. Students’ feedback about benefits from the ACCESS program (n=11 respondents)

All ACCESS scholars were overall happy with the ACCESS program, with 100% stating that they will very likely or somewhat likely recommend the ACCESS program to their classmates, as can be seen in Figure 7.

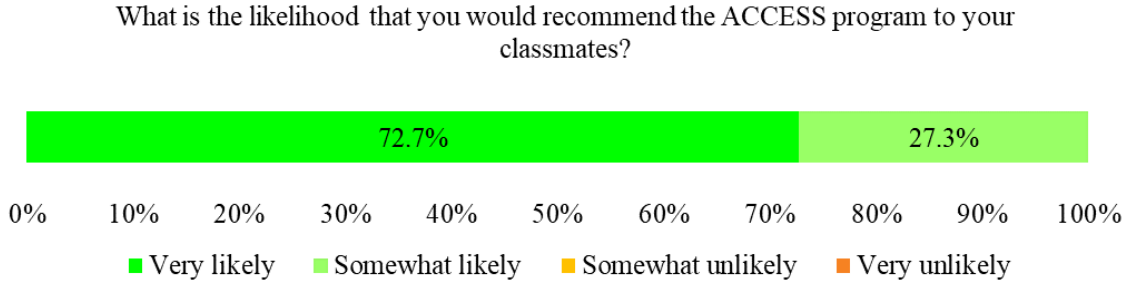

Figure 7. Students’ feedback about benefits from the ACCESS program (n=11 respondents)

6. Lessons learned

In sections 2-5 we presented the activities and accomplishments of the ACCESS project and their assessment based on the feedback provided by the students in the online survey and in-person focus group discussions. In this section, we summarize the lessons learned based on the ACCESS team and evaluation team observations and students' feedback.

- **Successful recruitment of a large number of excellent applicants** was due to ACCESS project recruitment strategies that were based on deliberate efforts to leverage different points of contact for students at different academic stages and across student identities. As a result, **the ACCESS team was able to select a total of 50 unique students in four cohorts.** This contributed to the steady increase of the enrollment in the B.S. and AoE in cybersecurity at the West Virginia University. Overall, the gender diversity of the ACCESS scholars is higher while the racial diversity is slightly lower than among students enrolled in the cybersecurity field at West Virginia University. In addition to the current recruitment activities, such as reaching out to student groups and professional organizations that represent women and people of color, to improve diversity within future cohorts the ACCESS team plans to expand the recruitment to additional high schools and community colleges.

- **Social events and community building.** 91% of the scholars in Year 4 indicated that they found the social events to be very or somewhat valuable, which is a significant increase compared to only 29% in Year 3. Similarly, a significant increase in positive feedback was reported on the ACCESS award ceremony (from 33% in Year 3 to 73% in Year 4). Even more, the feedback on community building and developing relationships with peers in the cybersecurity discipline was increasingly positive, from 50% in Year 3 to 64% in Year 4. It appears that as ACCESS activities transitioned from online to in-person after the COVID-19 pandemic, social events and community-building experiences were noticeably more valued by the ACCESS scholars.

- **Mentoring.** Overall, the students' feedback on meetings with faculty mentors was similar in 2023 to the previous years, with around 70% of ACCESS scholars finding these meetings to be very or somewhat valuable to their development as cybersecurity professionals [19]. Currently, the ACCESS team requires scholars to meet with their faculty mentor at least once per semester. Some students indicated that they would like to meet faculty mentors more often in person, including outside of school [19]. The ACCESS team plans to encourage more frequent meetings between scholars and mentors, as well as provide tips to the students on what a meeting request could look like and how to proactively request a meeting with a mentor. Additionally, the ACCESS team will work on aligning students' and mentors' expectations.

- **Students expressed the need to improve their communication and interpersonal skills**. Students felt that they could benefit from guidelines and suggestions on how to approach guest speakers, how to introduce themselves, how to ask a question, and how to "just talk to them normally". The ACCESS team intends to organize, in collaboration with the West Virginia University's Career Services Center, a seminar focused on the development of soft skills that would help students communicate more efficiently with cybersecurity

professionals and employers. In addition, faculty mentors and course instructors will be encouraged to address these topics in their interactions with students.

- **Summer internship was more popular than undergraduate research** among ACCESS scholars, even though both are optional ACCESS activities and typically are paid. For example, in summer 2023 out of 18 active scholars, 11 scholars had paid summer internships and only 2 scholars had paid research positions. Similarly, getting a full-time job after graduation was much more frequent than enrolling in graduate school. Of the 11 ACCESS scholars who have graduated thus far, 10 have started full-time jobs and only one student enrolled in an M.S. program.

- **The majority of ACCESS scholars were CyberWVU members.** CyberWVU is a student run organization centered on cybersecurity and participation in its work is one of the optional ACCESS activities. Nevertheless, over the years 70% - 89% of ACCESS scholars were CyberWVU members, likely because this activity supported the development of students' technical skills and provided community-building opportunities [19].

- **Seminars and panels** were among the most appreciated ACCESS activities, providing exceptional value to students [18] who consistently gave them high positive scores. Specifically, each year 82%-100% of scholars found the seminars and panels to be very or somewhat valuable for their development as cybersecurity professionals. Qualitative responses from annual surveys and focus group discussions showed that seminars and panels provided numerous benefits such as exposure to the current trends and industry practices of the rapidly changing field of cybersecurity, provided opportunities to connect with professionals, to learn about different career paths, and to gain the knowledge and confidence needed to secure an internship or full-time position. Students recommended increasing the networking time at seminars to allow more time for informal discussions with guest speakers. Since seminars and panels were open to all West Virginia University students, they had far-reaching benefits to a wide student population and helped publicize the ACCESS program and the B.S. and AoE in cybersecurity.

- **ACCESS program impact on academic achievements.** In addition to the explicit benefits described in this paper, the ACCESS project has indirectly impacted students' academic achievements and helped them get better grades. Thus, the program has boosted scholars' self-motivation and interest in cybersecurity, indirectly motivating them to work harder in their courses. Some students added that the ACCESS program GPA requirement is a motivation to get good grades. Some students also noted that the financial aid has allowed them to focus more on their academics than on work to pay for tuition and living expenses. As one scholar has stated: "I can focus more on my education and less on getting those hours in at work, so I can pay my tuition, pay my rent, everything. It just lets me breathe a little bit and focus on my grades, focus on my studies."

7. Conclusion

In four years, the ACCESS team has created and successfully implemented multiple activities that led to achieving all four project's objectives. This paper presented the ACCESS achievements, which for each objective are briefly summarized as follows:

- The ACCESS project has successfully awarded 68 annual scholarships (each in amount of $5,000) to 50 unique students, 11 of whom have already graduated and entered the cybersecurity workforce. The ACCESS project has achieved its objective 1 to increase the Cybersecurity B.S. and AoE enrollment at West Virginia University – from 19 students U.S. citizens in spring 2019 to 107 students U.S. citizens in spring 2023, despite the challenges of the COVID-19 pandemic in 2020 and 2021. To accomplish this objective, the ACCESS team and scholars engaged in numerous outreach and recruitment efforts at the university and high school levels.

- To achieve objective 2, the ACCESS project has enriched scholars' educational experiences and aided their success by providing co-curricular activities and support services. These included social events, such as the Award Ceremonies and less formal Get Together meetings. Furthermore, scholars regularly met with their faculty mentors, and were encouraged to join the CyberWVU student organization and participate in research.

- The ACCESS project has deepened the existing partnerships and has established new partnerships with numerous cybersecurity employers (objective 3). Prominent cybersecurity experts offered 16 seminars and panels during seven semesters. Even more, the active collaboration with cybersecurity employers provided ample opportunities for internship and full-time positions to ACCESS scholars.

- Last but also important, the impacts of ACCESS activities on student academic success, professional identity, and sense of belonging were assessed via annual survey and focus group interviews (objective 4). The research results indicated that ACCESS activities had significant positive impact on student success, their sense of belonging and their confidence about starting a career in cybersecurity.

Overall, students' feedback about the ACCESS program was overwhelmingly positive and highlighted numerous benefits of the program. 100% of ACCESS scholars stated that they will recommend the ACCESS program to their classmates.
Based on the observations made by the project and evaluation teams and students' feedback, we have synthesized the lessons learned and presented them in this paper. These lessons learned can be institutionalized at West Virginia University and elsewhere in higher education.

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9. References

[1] Cybersecurity Supply/ Demand Heat Map, https://www.cyberseek.org/heatmap.html. [Accessed Feb 7, 2024].

[2] Bureau of Labor Statistics, U.S. Department of Labor, Occupational Outlook Handbook, Information Security Analysts, https://www.bls.gov./ooh/computer-and-information-technology/information-security-analysts.htm. [Accessed Feb 7, 2024].

[3] B.S. in Cybersecurity, Lane Department of Computer Science and Electrical Engineering, Statler College, West Virginia University, https://admissions.wvu.edu/academics/majors/cybersecurity. [Accessed Feb 7, 2024].

[4] Area of Emphasis in Cybersecurity, Lane Department of Computer Science and Electrical Engineering, Statler College, West Virginia University, http://catalog.wvu.edu/undergraduate/collegeofengineeringandmineralresources/lanedepartmentofcomputerscienceand/computer_science/#areaofemphasistext. [Accessed Feb 7, 2024].

[5] O. Pierrakos, T. K. Beam, J. Constantz, A. Johri, and R. Anderson, "On the development of a professional identity: Engineering persisters vs. engineering switchers," in Proceedings of the *Annual ASEE/IEEE Frontiers in Education Conference*, San Antonio, TX, 2009, pp. 1-6.

[6] B. E. Huges, W. J. Schell, B. Tallman, R. Beigel, E. Annand, and M. Kwapisz, "Do I think I'm an engineer? Understanding the impact of engineering identity on retention," in Proceedings of the *2019 ASEE Annual Conference & Exposition*, Tampa, Florida, 2019.

[7] S. Krause-Levy, W. G. Griswold, L. Porter, and C. Alvarado, "The relationship between sense of belonging and student outcomes in CS1 and beyond," in Proceedings of the *17th ACM Conference on International Computing Education Research (ICER 2021)*, Virtual Event, 2021, pp. 29-41. https://doi.org/10.1145/3446871.3469748

[8] D. Christensen and I. Villanueva, "What do undergraduate engineering students at the onset of emergency hybrid learning during COVID-19 say about peer mentorship?" in Proceedings of the *2022 ASEE Annual Conference & Exhibition*, June 2022, Minneapolis, MN.

[9] M. L. Pedler, R. Willis, and J. E. Nieuwoudt, "A sense of belonging at university: Student retention, motivation and enjoyment*," Journal of Further and Higher Education*, Vol. 46, No. 3, pp. 397 – 408, 2022, https://doi.org/10.1080/0309877X.2021.1955844

[10] K. Cherry, "Maslow's hierarchy of needs. Maslow believed that physiological and psychological needs motivate our actions." Updated on August 14, 2022, https://www.verywellmind.com/what-is-maslows-hierarchy-of-needs-4136760. [Accessed Feb 7, 2024].

[11] M. Y. Ahn and H. H. Davis, "Four domains of students' sense of belonging to university," *Studies in Higher Education*, Vol. 45, No. 3, pp, 622-634, 2020, https://doi.org/10.1080/03075079.2018.1564902

[12] M. M. D. Suan and C. I. Magallanes. "Sense of belonging and self-esteem of high school students in a Catholic college" *Philippine Social Science Journal,* Vol. 3, No. 2, pp. 87-88, Sept/Oct. 2020, https://doi.org/10.52006/main.v3i2.174

[13] S. N. Wosu, "Framing cultural bridges for relational mentorship," in Proceedings of the *2023 Collaborative Network for Computing and Engineering Diversity (CoNECD)*, New Orleans, Louisiana, Feb. 2023, https://peer.asee.org/44797

[14] B. D. McPheron, "Work-in-progress: Applying peer mentorship in a first year engineering course to improve student learning and retention outcomes," in Proceedings of the *2022 ASEE IL-IN Section Conference*, 2022.

[15] K. A. Landry, N. M. Jackson, and K. G. Finley, "A STEM mentorship program to improve veteran student efficacy at Georgia Southern University - Year 1," in Proceedings of the *2017 ASEE Annual Conference & Exposition*, Columbus, Ohio, June 2017.

[16] B. Przestrzelski and C. A. Roberts, "The industry scholars mentorship program: A professional industry connection experience for engineering undergraduates," in Proceedings of the *2019 ASEE Annual Conference & Exposition*, Tampa, Florida, June 2019.

[17] K. Goseva-Popstojanova and R. A. M. Hensel, "Educating the Next Generation of Cybersecurity Experts", in Proceedings of the *2021 ASEE Annual Conference & Exposition*, July 2021, Virtual conference. https://peer.asee.org/37000

[18] K. Goseva-Popstojanova, E. Carll, E. Litzler and R. Hensel, "Building S-STEM scholars' knowledge and skills through technical and career-development seminars", in Proceedings of the *2022 ASEE Annual Conference & Exposition,* June 2022, Minneapolis, MN, https://peer.asee.org/42023

[19] K. Goseva-Popstojanova, E. Carll, and R. Hensel, "On the ACCESS project support for students' academic success in the cybersecurity field," in Proceedings of the *2023 ASEE Annual Conference & Exposition,* June 2023, Baltimore, MD, https://peer.asee.org/board-353-on-access-program-support-for-students-academic-successin-the-cybersecurity-field.pdf

[20] R. Hensel and K. Goseva-Popstojanova, "Development of a cybersecurity professional identity", in Proceedings of the *2022 ASEE Annual Conference & Exposition, Computing & Information Technology Division Paper,* June 2022, Minneapolis, MN, https://peer.asee.org/41591

[21] R. Hensel, K. Goseva-Popstojanova, and S. Sarwari, "Sense of belonging in cybersecurity field of study", in Proceedings of the *2023 ASEE Annual Conference & Exposition, Computing & Information Technology Division Paper,* June 2023, Baltimore, MD, https://peer.asee.org/44196

[22] G. Crisp, V. L. Baker, K. A. Griffin, L. G. Lunsford and M. J. Pifer, "Mentoring undergraduate students," *ASHE Higher Education Report, Vol. 43, No 1*. 2017, John Wiley & Sons.

[23] L. DeAngelo, J. Mason and D. Winters, "Faculty engagement in mentoring undergraduate students: How institutional environments regulate and promote extra-role behavior." *Innovative Higher Education,* Vol. 41, No. 4, pp. 317–32, 2016.

[24] K. Goseva-Popstojanova "Recruitment and education of the future cybersecurity experts", *AAAS 2021 Virtual S-STEM Fall Forum*, Sept. 30 – Oct. 1, 2021, Abstract, YouTube recorded presentation (https://youtu.be/Rp4QqfsfUOQ). [Accessed Feb 7, 2024].

[25] K. Goseva-Popstojanova "ACCESS project activities in support of cybersecurity education," *AAAS 2022,* Washington, DC, Sept. 29 – Oct. 1, 2022, Abstract & Poster.

[26] K. Goseva-Popstojanova "Research on software vulnerabilities and educational activities of the ACCESS program: A tale of two cybersecurity projects", *Fall CyberTalk for the CyberConnect Mentoring Program, University of Maryland at College Park*, November 16, 2023.