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Development of a Cybersecurity Professional Identity

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Development of a Cybersecurity Professional Identity

ABSTRACT

Cybersecurity is a relatively new field in higher education and cybersecurity professionals are essential for protecting our nation's infrastructure and ensuring public safety and national security. Cybersecurity employment opportunities in the U.S. are expected to grow much faster than the average growth of all occupations in the U.S. over the next decade [1]. Because of the strong employment outlook and the criticality of these positions to our economy and national security, universities are developing cybersecurity education programs. One large, land-grant, R1 university in the mid-Atlantic region has developed a new B.S. degree in Cybersecurity and an Area of Emphasis (AoE) in Cybersecurity for Computer Science, Computer Engineering and Biometric Systems Engineering majors. These educational initiatives aim to produce work-force ready cybersecurity experts who will fill the growing demand for cybersecurity professionals.

Past research has shown that the development of a positive engineering identity contributes to increased retention and persistence within engineering fields [2]. One goal of the NSF S-STEM ACCESS program is to increase student engagement with professional development activities to help students develop a positive professional cybersecurity identity. S-STEM scholars, however, are selected based on academic success and prior academic engagement which may influence their level of participation and persistence in their degree program. Three questions arise: (1) Are there early signs that ACCESS scholars will have higher academic achievement and persist at higher rates than non-ACCESS scholars among cybersecurity students? (2) Do students participating in the ACCESS program participate in more professional development activities than students in a comparison group?" and (3) What elements of the S-STEM ACCESS program do students find most helpful in supporting their development as cybersecurity professionals?

This research will inform Cybersecurity educational programs about the elements which contribute positively to the development of a Cybersecurity professional identity, and whether or not student engagement in these activities may impact expected student retention and persistence as measured by the Grit survey. The Grit scale measures "the extent to which individuals are able to maintain focus and interest, and persevere in obtaining long-term goals." [3, 4]. Used as a predictive indicator of expected retention and persistence, the Grit tool was employed to assess characteristics of nine S-STEM scholarship recipients and their peers in four courses: a freshman level introduction to data structures course with 139 students enrolled, a sophomore level computer system concepts course with 89 students enrolled, and two upper-level cybersecurity courses – "Secure Software Development" and "Practicing Cybersecurity: Attacks and Countermeasures" with 25 and 35 enrolled students, respectively. Since there were no first-year students in the first ACCESS cohort, results from the freshman-level introduction to data structures course may be less relevant for this study but were included as a baseline. Future cohorts are expected to have first-year students.

We also address the intentional selection bias of the S-STEM ACCESS scholar cohorts which may predispose them to have higher student success and participation measures. Student engagement programmatic elements are included along with results from the survey responses

and typical student success measures with a goal to determine which activities and programmatic elements students find most helpful in supporting their development as cybersecurity professionals and their persistence in the cybersecurity major. Because the group of S-STEM scholars is so small, we use qualitative analyses to assess their perspectives on whether and how S-STEM ACCESS program elements contribute to their professional development. Data from S-STEM ACCESS program participants suggest that the program supports scholars with respect to our measures of interest and that they found the technical and professional seminar series and opportunities to gain practical experience particularly helpful for their professional development.

1.0 Introduction

Cybersecurity is a new field of study with very high market demand. Since cybersecurity is critical to all areas of public life, including the economy and national security, cybersecurity professionals are in very high demand currently and the job market is expected to "grow 33 percent from 2020 to 2030, much faster than the average for all occupations" [1]. To meet this national need, West Virginia University has developed a B.S. degree program in Cybersecurity and an undergraduate Area of Emphasis (AoE) in Cybersecurity for students enrolled in existing departmental majors, such as Computer Science, Computer Engineering, and Biometric Systems Engineering. Throughout this paper, "cybersecurity students" will refer to all students enrolled in either the B.S. degree program or the AoE in Cybersecurity. Goals for the new programs include increasing enrollment by recruiting students from diverse populations and developing extra-curricular support services and activities to enhance the overall student educational experience, promote academic success, and facilitate retention and persistence to graduation. For our purposes, retention refers to first-to-second year continuation in the program and persistence refers to continuation past the second year to graduation.

Supported by an NSF Division of Undergraduate Education (DUE) S-STEM funded project, the ACCESS program provides scholarships and professional development opportunities for qualifying students pursuing a B.S. major or AoE in Cybersecurity. To qualify, students must demonstrate high achievement and have financial need. In its first year (AY 2020-2021), nine ACCESS scholarships, including four members of ethnic or racial minority groups (44% of cohort) and four women (44% of cohort), were awarded.

Each of the three research questions are investigated as described below.

- Research Question 1: "Are there early signs that ACCESS scholars will have higher academic achievement and persist at higher rates than non-ACCESS scholars among cybersecurity students?" To investigate this question, we use GPA to compare academic achievement and the Grit assessment to provide a measure of expected persistence. The ACCESS scholars' cohort data are compared to a comparison group of all students in the defined comparison group who responded to those questions of the survey. Additionally, to investigate whether or not any identified difference may be due to a potential selection bias, we used a matched sample to assess whether or not the results are robust across methods.
- Research Question 2: Do students participating in the ACCESS program participate in more professional development activities than a comparison group of cybersecurity students? To investigate this question, student participation data is used to compare

student engagement in different professional development activities between the ACCESS scholars' cohort and the defined comparison group.

- Research Question 3: "What elements of the S-STEM ACCESS program do students find most helpful in supporting their development as cybersecurity professionals?" To investigate this question, qualitative data from ACCESS scholars' responses to survey questions and focus study questions are used.

2.0 Background

What elements contribute positively to the development of a cybersecurity identity and student retention, persistence and academic success? In spring 2021 the researchers employed a survey to measure elements related to professional identity development and expected student retention and persistence. Before these data are analyzed, however, a foundational question about the entering differences between the selected ACCESS students and the general population of cybersecurity students must be assessed. While information is presented about the professional development activities provided for the ACCESS scholars and the other cybersecurity students, the first research question provides a preliminary analysis related to the selection bias of the ACCESS scholars, especially as it relates to specific measures of expected persistence and academic success. By benchmarking these initial differences, future analysis related to the effect of aspects of the ACCESS program will be stronger and more complete.

Since student engagement appears to influence students' development as STEM professionals, all cybersecurity students were encouraged to participate in a variety of cybersecurity-related and STEM-related student organizations, ACCESS-sponsored cybersecurity-related seminars, and other social or athletic groups. In addition, during the 2020/21 school year five ACCESS-sponsored technical and career-development seminars were offered in which cybersecurity professionals presented state-of-the-art topics, discussed industry practices, and provided career advice related to securing a security clearance or internship opportunity [5]. Active engagement in profession-related student organizations provide opportunities to practice work-related skills, while seminars offer an intellectual setting that differs from a traditional classroom [6] and may give students freedom to "learn purely for the sake of learning" without, for example, focusing on how that learning will be evaluated for a grade [7]. These pre-graduation professional development opportunities promote occupational socialization by creating environments in which students engage directly with practicing professionals and learn the expectations and work norms of the cybersecurity profession [8]. Differences between the participation of ACCESS scholars and other cybersecurity students in these professional development opportunities are presented.

Expected persistence and academic success can be measured in multiple ways considering the effects of motivation, self-efficacy, grit, and achievement. This work uses GPA to measure academic success and grit and its sub-scores to predict expected persistence.

3.0 Methodology

A survey was developed and administered during the spring 2021 semester to the first cohort of NSF S-STEM ACCESS scholars and to students in four Cybersecurity courses that are part of the curriculum for the B.S. degree and AoE in Cybersecurity. Students were requested to take the survey one time (even if they were enrolled in multiple courses). The survey included basic

academic information (academic level and GPA), seventeen Grit-assessment [3] questions, and questions related to their experience and continued interest in the cybersecurity field of study. Also, since all students did not answer all survey questions, but had the option to leave items unanswered, the sample sizes for each item assessed below vary based on the number of students who answered the specific survey items being assessed. In each case, the treatment group was composed of the students in the S-STEM ACCESS program and the comparison group was composed of students who were not in the ACCESS program but were enrolled in spring 2021 in one of the four courses that are also part of the cybersecurity B.S. degree program and AoE. These four courses include: a freshman level introduction to data structures course with 139 students enrolled, a sophomore level computer system concepts course with 89 students enrolled, and two upper-level cybersecurity courses – "Secure Software Development" and "Practicing Cybersecurity: Attacks and Countermeasures" with 25 and 35 enrolled students, respectively. Since there were no first-year students in the first (AY 2020-2021) ACCESS cohort, results from the freshman level introduction to data structures course may be less relevant for this study but were included as a baseline. Future cohorts are expected to have first-year students.

3.1 GPA

Since GPA is one measure of student academic success, it was used to address the academic achievement part of research question 1. The self-reported GPAs of the ACCESS scholars were compared to the self-reported GPAs of the comparison group. First, the data was cleaned; all surveys with non-reported GPAs were removed from the data set, yielding nine GPAs reported for the ACCESS scholar group and 207 GPAs reported for the comparison group. Next the GPAs were compared to determine if there was a significant difference between them. Because ACCESS scholars were selected, in part, based upon their GPAs, an intentional selection bias is expected to be evident in the comparisons of GPA distributions between the ACCESS students and the comparison group. Knowing and recognizing the size of that bias will facilitate more accurate analysis of current and longitudinal investigations of measures of student success and related measures of persistence.

3.2 Grit

Students who retain past their first year and persist to graduation are expected to demonstrate "grit," defined as "passion and sustained persistence applied toward long-term achievement, with no particular concern for rewards or recognition along the way" [4]. Since this is the first year of the study and we do not have longitudinal persistence data, we use the Grit score to measure the expected persistence of students to address the persistence part of research question 1. The 17-item Grit survey was developed to measure this characteristic using a 5-point Likert scale in which subjects indicate the degree to which relevant statements "are like" them, using the scale: 1 = "Not like me at all," 2 = "Not much like me," 3 = "Somewhat like me," 4 = "Mostly like me," and 5= "Very much like me." The Grit survey contains some items that are coded in the opposite order. To address this and make sure the scoring system for all the items we analyze consistently correspond with a higher level of "grit", we reverse-coded seven survey items. [3,4]. Once the reverse-coded scores were addressed, the Grit score was computed by summing all 17 survey item responses. Additionally, the Grit score contains four sub-scores: the Brief Grit sub-score, the Consistency of Interest sub-score, the Perseverance of Effort sub-score, and an Ambition sub-score.

The Grit assessment was used to measure student's expected persistence in the Cybersecurity major or AoE. The results of the Grit survey were summarized and analyzed to determine any differences between the two groups related to Grit or to any of the Grit sub-scores. Because the difference in population sizes was so large between these groups (nine ACCESS scholars and 302 cybersecurity students in the comparison group), the data were analyzed using two different approaches. In the first approach, all survey results were considered, comparing the results from the nine ACCESS scholars to the results from the 302 students in the comparison group (i.e., the complete comparison group) using a Welch's t-test for independent samples, unequal samples, and unequal variances. The second approach attempted to account for the GPA difference and group size difference by comparing a sample of the 302 students in the Complete comparison group (students enrolled in one of the four courses that are also part of the cybersecurity B.S. degree program and AoE) that is the same size and relative composition to the much smaller ACCESS scholar group. Recognizing that the ACCESS scholar group was composed of students with higher GPAs than the average GPA of the comparison group, nine students were randomly selected within representative GPA bands, as shown in Table 1 below, creating the sample "matched" comparison group.

Table 1. Selection schema for "Matched" comparison group sample

ACCESS student GPA		**Number of GPAs in Comparison Group**	**Number of Randomly Selected Student Scores**
Below Min or Not Reported		194	
Min	3.30	63	1
Q1	3.74	3	2
Median	3.78	14	2
Q3	3.89	13	2
Max	4.0	15	2

A total of 9 students were selected by randomly selecting one from the 63 students with GPAs between 3.30 and 2.739, two students from the three students with GPAs between 3.74 and 3.779, two students from the 14 students with GPAs between 3.78 and 3.889, two students from the 13 students with GPAs between 3.89 and 3.999, and two students from the 15 students with 4.00 GPAs. While not a direct "paired sample", the resulting sample of the comparison population provides a better "matched" group to the ACCESS scholars. This newly created sample also was compared to the ACCESS scholars on Grit score and sub-score measures. For clarity, the term "Complete comparison group" will be used to refer to the larger population of non-ACCESS students who complete the survey and the "Selected comparison sample" will be used to refer to the smaller sample drawn from the comparison group.

3.3 Student Confidence

Another measure of student persistence may be the students' indicated current level of confidence that they will complete an engineering, computer science, or cybersecurity degree. Since students in the four classes are pursuing engineering, computer science or cybersecurity degrees, the survey asked a question related to their confidence that they will complete one of these degrees. This data is presented below in section 4.3 and used as another indicator for student expected persistence.

3.4 Student Engagement

Additional survey questions were analyzed to determine the professional development activities in which the students participated to address research question 2. Comparisons were made between participation levels of the ACCESS scholars and the complete comparison group. These results are presented in section 4.4 below.

3.5 Perceived value of ACCESS-sponsored Experiences

Survey questions and results from focus group responses about which activities they found to be most helpful to their career and development were used to address research question 3. These qualitative results are shared in section 4.5 below.

4.0 Results

To address research question 1, the survey responses for GPA and Grit measures from these two populations are summarized and the results are presented in sections 4.1 and 4.2. Additionally, student confidence in persisting in their selected B.S. degree major or AoE is addressed in section 4.3. Research question 2 is addressed using student self-reported engagement data presented in section 4.4 and research question 3 is addressed using qualitative survey results and focus group results presented in section 4.5 below.

4.1 GPA

The results of the GPA comparison between the self-reported GPAs of the ACCESS scholars and comparison group students are summarized in Table 2, below, using a 5-number summary (minimum, 1st quartile, median, 3rd quartile, and maximum).

Table 2. Comparison of self-reported GPAs of ACCESS students and comparison group students

Self-reported GPA	Min	Q1	Median	Q3	Max
ACCESS	3.30	3.75	3.80	3.92	4.00
COMPARISON	1.90	3.08	3.30	3.61	4.00

The distributions of both data sets are illustrated in Figure 1.

Figure 1. Comparison of self-reported GPA distributions of ACCESS scholar GPAs and the Complete comparison group GPAs.

Clearly, and not surprisingly, these two data sets have distinctly different distributions and unequal variances, as supported by the results of the two-tailed F-test, in which the null hypothesis was rejected in favor of the alternative hypothesis that the variances are not equal at the 0.05 level of significance ($p = 0.0196$). Based on that information, the hypothesis that the mean GPAs were equal was tested using the two-tailed Welch's t-test for independent samples with unequal variances. The null hypothesis was rejected in favor of the alternative hypothesis that the mean GPAs of the ACCESS group and the Complete comparison group are not equal ($p=0.000039$). Results of a one-tail t-test support the conclusion that the mean GPA of the ACCESS scholars is statistically significantly higher than the mean GPA of the Complete comparison group students ($p=2.3577 \times 10^{-5}$).

The difference matches expectations since the ACCESS scholars were selected, in part, based on academic achievement. GPA was considered as part of the application, so it appropriately follows that the mean GPA of the ACCESS scholars is significantly higher than the mean GPA of the participating students in the Complete comparison group. This selection bias must be noted in any future comparisons of results for the two groups.

4.2 Grit

Results of the 17-item Grit survey yield an overall "Grit" score and four sub-scores: Consistency of Interest, Perseverance of Effort, Brief Grit, and Ambition. The Grit score is calculated as a sum of each of the 17 measures, and each sub-score is a sum of the subset of measures associated with each sub-score measure.

The average overall Grit score was 2.75 for the ACCESS Scholars and 2.77 for the Complete comparison group, with variances of 0.20 and 0.34, respectively. The Grit of both populations

appear to be relatively similar but have differing distributions (indicated by the difference in variance). Interestingly, the mean Brief Grit score, computed using only eight of the original 17 measures of Grit, yielded the same results as the full Grit score for both populations: 2.75 for the ACCESS scholars and 2.77 for the Complete comparison group; but the variances differed (0.27 ACCESS data; 0.45 Comparison data).

Next the two sub-scores, *C*onsistency of Interest and Perseverance of Effort, were computed for both populations. For the Consistency of Interest variable, the mean score for the ACCESS scholars was 1.59 and the mean of the Complete comparison group was 1.79. The variances were 0.41 and 0.69, respectively. While the comparison group had a broader distribution, the mean appeared to be somewhat higher than the ACCESS group mean, but the difference was not statistically significant. The mean Perseverance of Effort score was 3.91 for the ACCESS scholars and 3.75 for the Complete comparison group, with variances of 0.24 and 0.37, respectively. For Perseverance of Effort, the less variable ACCESS scholar group appeared to have a higher mean score than the more varied comparison group, but the difference was not statistically significant.

Finally, the mean Ambition sub-scores were 4.20 for the ACCESS scholars and 3.60 for the Complete comparison group, with variances of 0.07 and 0.51, respectively. This difference was significant at the 0.05 level of significance ($p=0.00004$ [Welch's]). These results suggest that the group of ACCESS scholars on average have more ambition than their non-scholarship peers studying in a similar field. This result is not surprising, since having the drive to apply for and the academic credentials to be selected for the ACCESS scholars' program would likely correspond to a relatively high level of ambition. The large difference in variance appears to suggest that there is much greater variability in ambition among the Complete comparison group than there is in the smaller ACCESS scholar group. The Grit scores and the associated sub-scores are presented in Figure 2 below.

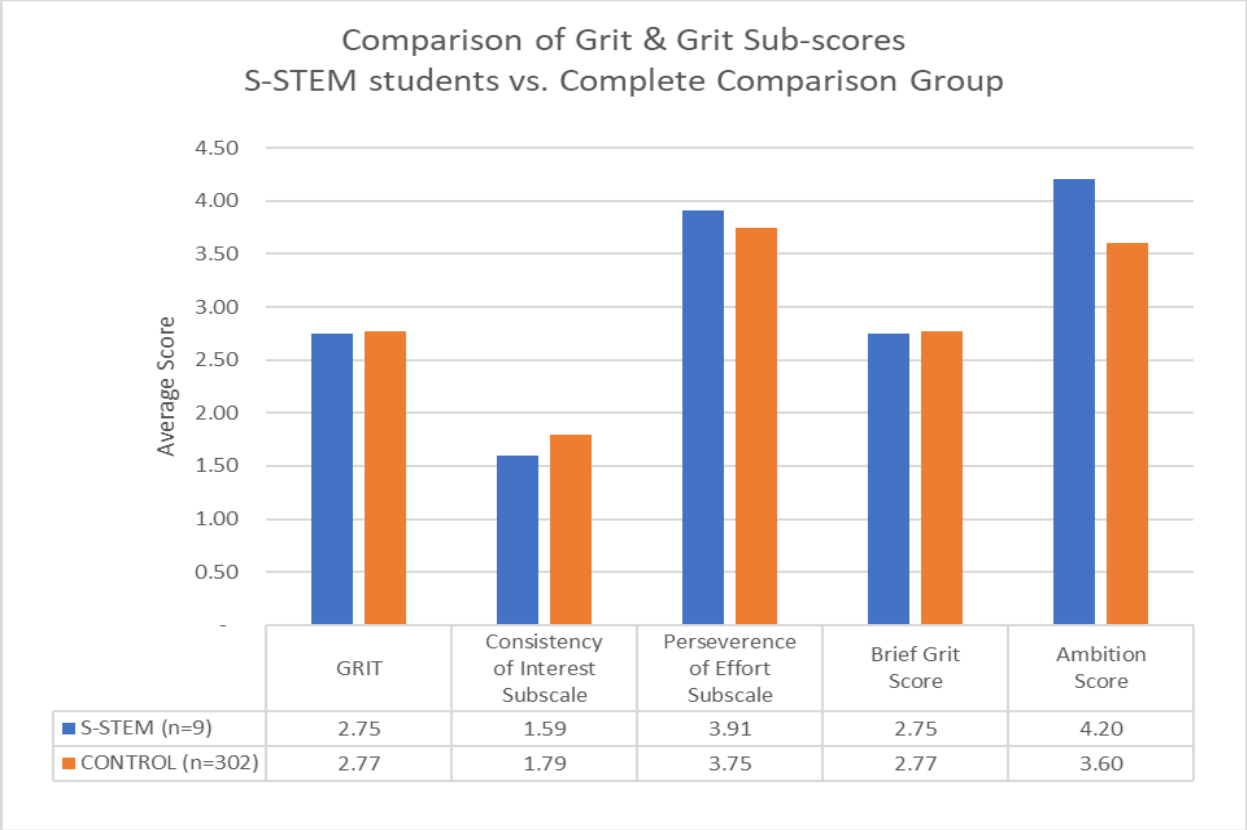

Figure 2. Comparison of Grit sub-scores between the ACCESS population and the Complete comparison group.

When comparing the 9-element Selected comparison sample to the group of ACCESS scholars, the Selected comparison sample, if anything, reported slightly higher scores in Grit and all the sub-scores, except for the Ambition sub-score, where the ACCESS group seemed to appear to be higher. No significant differences between the two groups were indicated for any of the sub-scores. With only nine data points, the sample is too small to have good statistical power. The comparison, however, is presented below in Figure 3. While the variances of the Grit and the Grit sub-scores were larger for the matched Selected comparison group than for the ACCESS scholar group for four of the five measures (the ACCESS variance was slightly greater only in the Perseverance of Effort score, 0.24 ACCESS variance to 0.23 matched comparison variance), the differences were much smaller.

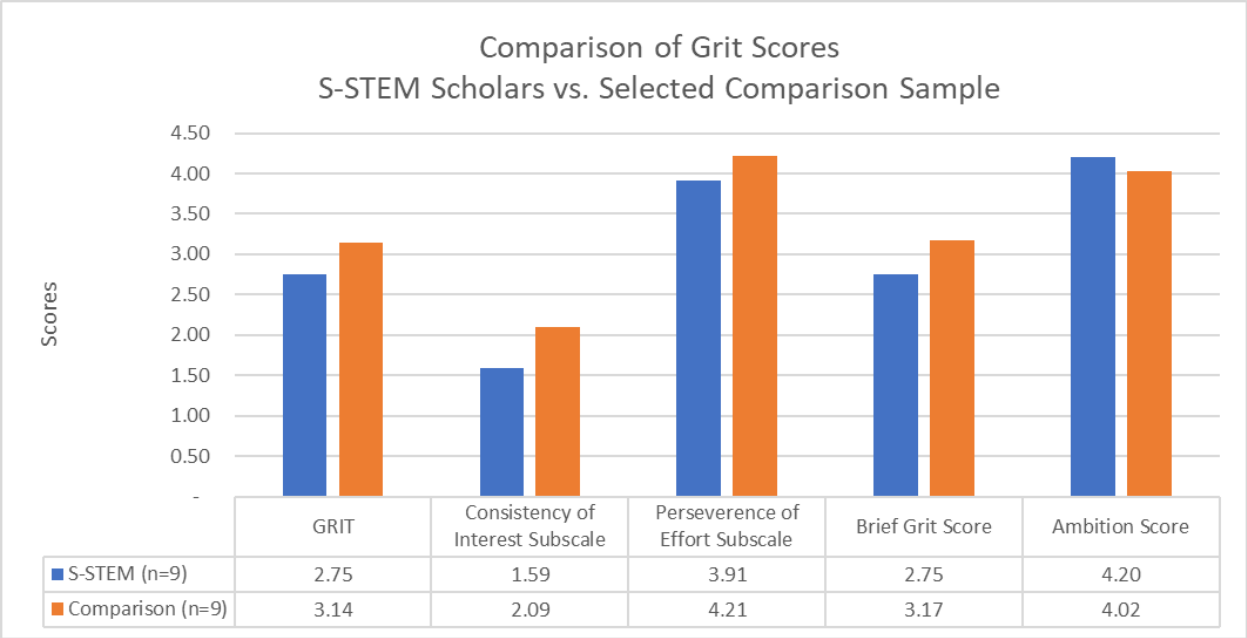

Figure 3. Comparison of Grit scores between the S-STEM ACCESS scholars' population and a similar size sample selected randomly from ranges of matching GPAs from the Complete comparison group (this newly created sample is called the Selected comparison sample).

While no differences are statistically significant, it appears that the ACCESS scholars have a higher mean Ambition score than the matched comparison group; but scored lower on all other Grit measures. While our analyses cannot explain the possibility that this higher-GPA sample of the comparison group has higher measures of grit, consistency, and perseverance, one plausible explanation is that more grit is necessary to make it through their programs with a relatively high GPA but without the support of the ACCESS program. As we suggest above, the higher level of ambition for ACCESS scholars may correspond to the necessary drive and effort to become a ACCESS scholar. Another possible explanation is that the support of the ACCESS program may provide the encouragement and structure to reach higher.

Other survey items analyzed were expected to provide insight into the development of a cybersecurity professional identity, including the students' beliefs about their likelihood to persist in their declared major or AoE.

4.3 Confidence

Confidence in one's ability or likelihood to persist in a major or AoE may be influenced by one's class level. For example, first-year students may have a more fluid idea of their major and be less confident in their ability to complete a specific major than a senior-level student. Hence, understanding the class level distribution of the ACCESS scholars and the Complete comparison group may be significant in any analysis of retention and persistence.

As shown in figure 4, the S-STEM scholar group was composed of two (22.22%) second-year (both with Junior-level credits) and seven (77.78%) third-year students (three with senior-level credit hours and four with junior-level credit hours) while the Complete comparison group was composed of 89 (29%) first-year college students, 87 (28%) second-year students, 64 (21%)

third-year students, 42 (14%) fourth-year students, and 26 (8%) fifth-year students. We note that some of the fifth-year students are pursuing dual majors that include Cybersecurity as one of the majors, requiring them to take longer to complete both majors.

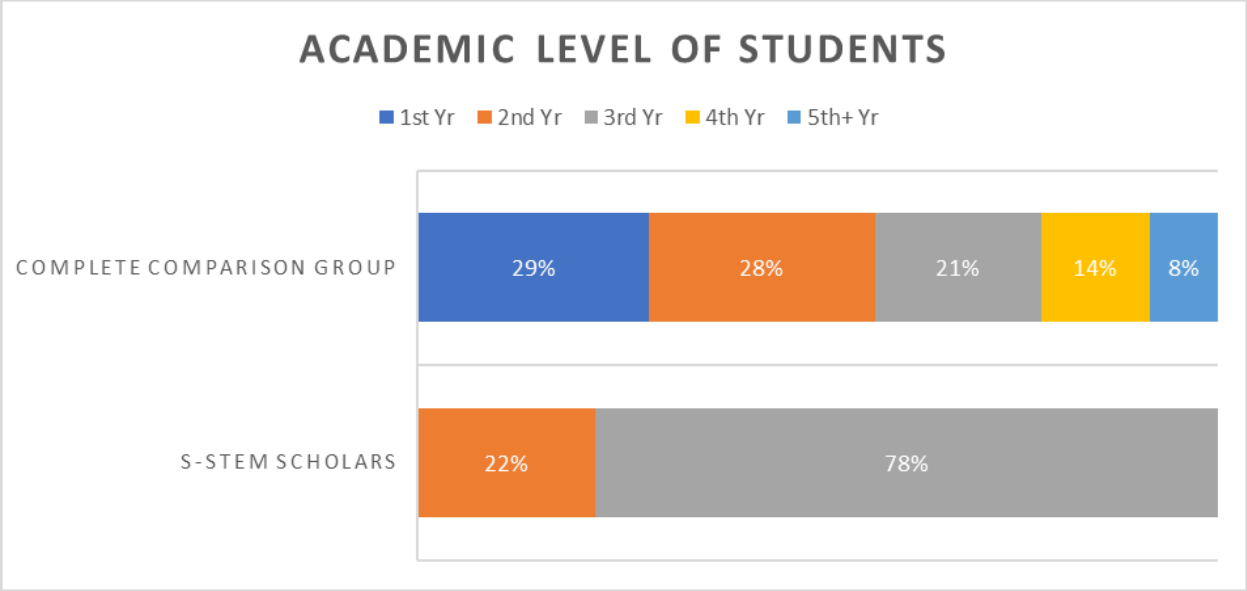

Figure 4. Academic level of S-STEM scholars in cohort 1 who completed the survey and of the students comprising the Complete comparison group who completed the survey.

When asked about their confidence that they will complete an engineering, computer science, or cybersecurity degree, 88.9% of the S-STEM scholars and 87.7% of the Complete comparison group students responded they were “fairly” or “very” confident. These results indicate an expected relatively high rate of persistence to graduation in their current major for all survey participants.

Figure 5 shows that while cohort 1 of the S-STEM scholars is composed of only second and third-year students, 100% of the second year students and 77.78% of third-year students are very confident about keeping their current major; while 11.11% of third-year students are fairly confident and 11.11% of third-year students indicate there is a 50% chance of keeping their major. Interestingly, and somewhat surprising, all second-year students are very confident in their choice, while the third-year student confidence is more variable.

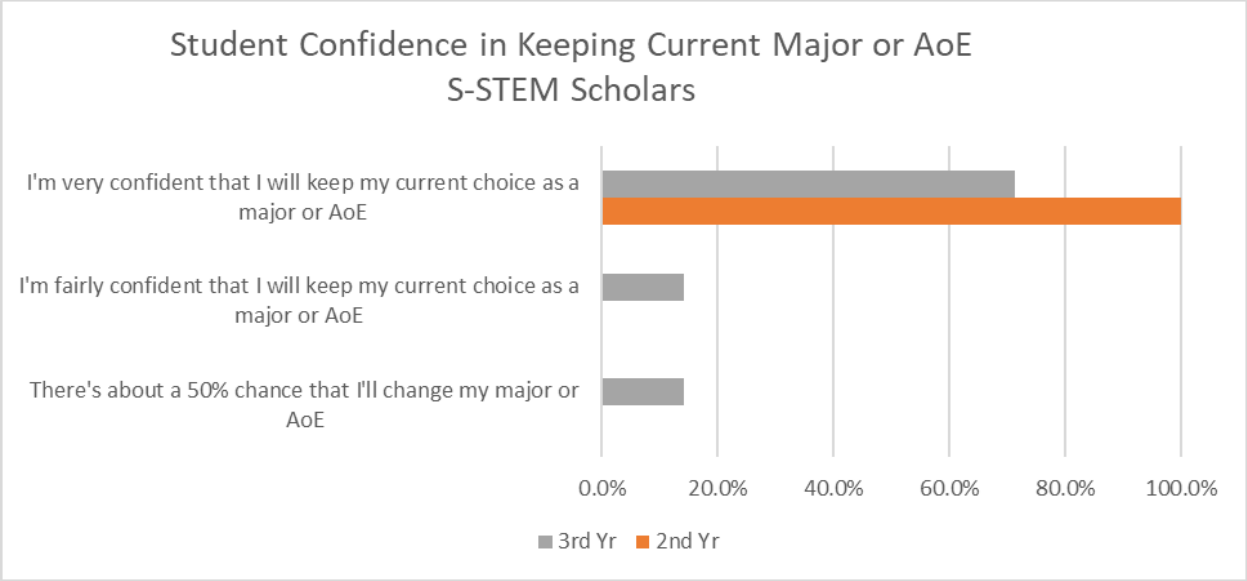

Figure 5. Expressed confidence in remaining in a cybersecurity-related major of ACCESS scholars, by level.

The much larger Complete comparison group contains students at all levels, from first-year to fifth-year students. By class, as shown in Figure 6 below, 78.7% of the first-year students indicate they are very (42.7%) or fairly (52.9%) confident in keeping their current major, but that percent increases to 90.8% of second year students, 93.8% of third year students, and 97.6% for fourth year students, and decreases to 91.7% for fifth year students.

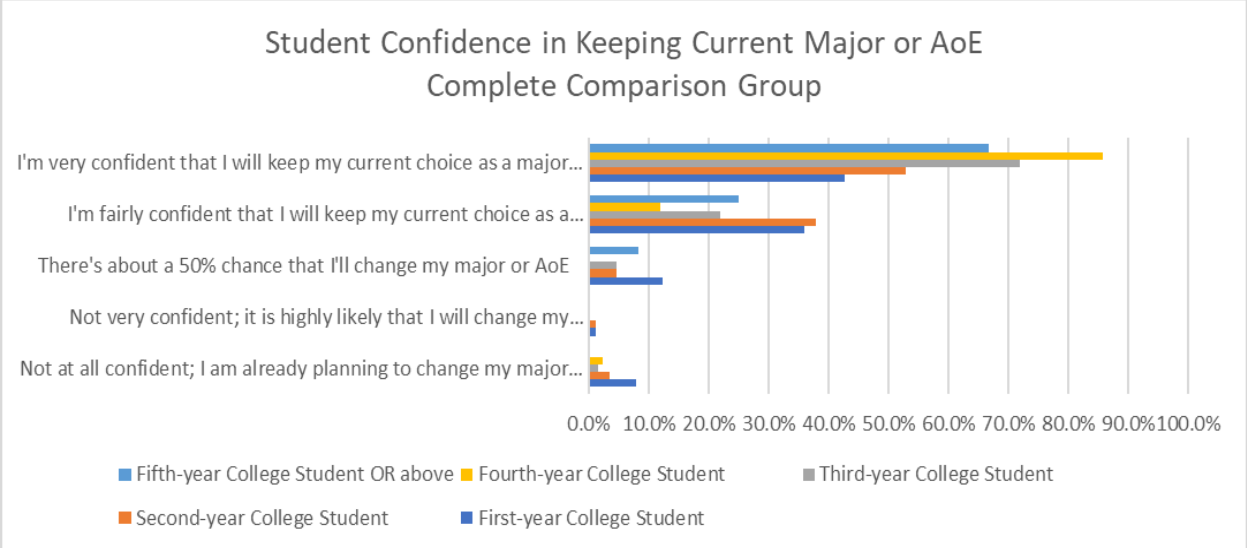

Figure 6. Expressed confidence in keeping current cybersecurity-related major of the members of the Complete comparison group.

One explanation for the surprising fall in confidence of persistence for fifth-year students is that many of these students may be pursuing dual majors and may be so close to graduation with one major that they may be considering dropping their second major.

Comparing student confidence in persisting in their major based on their academic level, it appears that S-STEM scholars, on average, have higher rates of confidence about keeping their cybersecurity major or AoE than do students in the Complete comparison group. This result, however, may be affected by the very limited population size and limited academic level of the S-STEM scholar participants. It may also be influenced by the scholarship itself; S-STEM scholars must remain in a cybersecurity major or AoE to continue to receive the scholarship funds. Since this is the first year of the first cohort of the S-STEM scholars, these students may be likely to express the intent to continue in the degree or AoE program that is funding a portion of their educational expenses.

4.4 Engagement

Since engagement in professional development activities is expected to facilitate the development of a professional identity and promote occupational socialization, students also were queried about their participation in a variety of professional development activities. Specifically, students were asked to indicate if they participated within the past year in any of the following activities: CyberWVU club, activities sponsored by their department or major, an intramural of university sports team, a social sorority or fraternity, IEEE student branch, the Society of Women Engineers (SWE) study chapter, the Associate for Computing Machinery (ACM) student organization, Engineers without Borders, Robotics club, Eta Kappa Nu, WVU Robots, the Student Society for the Advancement of Biometrics, the National Society of Black Engineers (NSBE), Alpha Omega Epsilon, the Society of Hispanic Professional Engineers (SHPE), Upsilon Pi Epsilon, or any other engineering or computer science society that was not listed.

Fifty-seven percent of the Complete comparison group students indicated they did not participate in any career-related extra-curricular activities in the past year; 13.3% participated in CyberWVU, 11.4% participated in activities sponsored by their department or major, and 10.1% participated on an intramural or university sports team. In contrast, all of the ACCESS scholars participated in at least one professionally-related extracurricular activity during the past year. In addition, 89% of ACCESS scholars participated in CyberWVU, and 22% of the ACCESS scholars participated in activities sponsored by their department or major, 22% participated in the Society for Women Engineers student organization, and 22% participated on an intramural or university sports team. These data are presented in Figure 7, below.

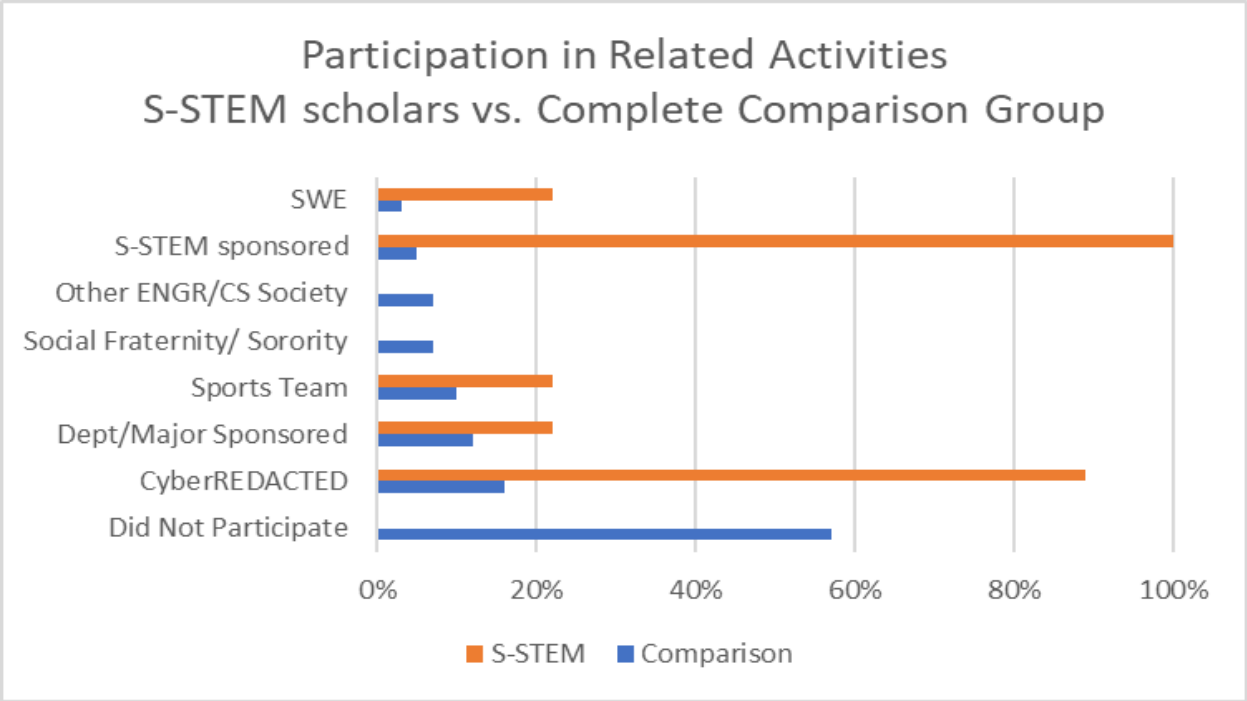

Figure 7. Comparison of the activities in which students participated in during AY 2020-2021, ACCESS scholars vs. Complete comparison group.

Student engagement in professional development generally helps to build confidence, increase persistence, and facilitate professional identity. ACCESS scholars are required to participate in some ACCESS program-sponsored activities, while others are optional. They also are not required to attend *all* of the required activities, but only *some* of them. All of the ACCESS scholars participated in at least one of the ACCESS-sponsored activities while only 5% of the Complete comparison group participated in any of the ACCESS-sponsored activities. Interestingly, while 100 % of the ACCESS scholars participated in at least one professional development activity, over half of the non-ACCESS students did not participate in any professional development activity in the 2020/21 school year. The participation difference can also be seen in CyberWVU, in which 89% of the nine ACCESS students participated, but only 16% of the Complete comparison group participated. This difference may, however, be partially explained by the make-up of the Complete comparison group. While this group is composed of students in cybersecurity-prerequisite computer science courses and in upper-level cybersecurity courses, some of the students in either the freshman level data structures course or in the sophomore level computer systems course may not be interested in pursuing a cybersecurity B.S. degree program or AoE. Those students would be less interested in participating in CyberWVU or other ACCESS sponsored activities.

While the data does not suggest that the higher level of participation in professional development activities is due to the ACCESS program, there is reason to believe this may be the case. For example, the ACCESS scholarship may free up time for activities that similarly socioeconomically disadvantaged students without the funding may have to spend earning money. Further, the small community of the ACCESS program personalizes communication between program staff and scholarship recipients and strong encouragement to participate from

familiar individuals may be more encouragement than the average student receives. However, the participation in professional development activities may also reflect the intentional selection bias for the ACCESS programs and/or the possibly higher ambition among ACCESS students. Those students who had significant ambition and academic credentials to apply and be selected for the ACCESS scholarship are those students who are likely predisposed to look for and engage in professional development opportunities that they understand can help them prepare for a successful career.

4.5 Perceived Value of ACCESS-sponsored Experiences

The NSF S-STEM ACCESS program facilitated several types of events, including: Technical and professional development seminars, CyberWVU club, summer internships, undergraduate research experiences, faculty mentors, social events, an initial scholarship award ceremony and opportunities to engage in k-12 outreach about cybersecurity. Student feedback was sought regarding the value of each experience offered.

With the exception of the ACCESS award ceremony, most ACCESS students found all ACCESS activities to be somewhat or very valuable. The award ceremony was the initial event welcoming the ACCESS scholars and introducing the NSF S-STEM research team, so it may have been viewed by students as a recognition event and not a professional development event.

Of those who responded, students expressed the highest value for the technical and professional development seminars and other networking and professional skill building opportunities. All ACCESS scholars rated the technical and professional development seminars as valuable, with 87.5% indicating they were very valuable and 12.5% indicating they were somewhat valuable. These results were supported by qualitative data, specifically open-ended survey responses and focus group input. In response to a question about their most valuable experience in the ACCESS program, most students mentioned seminars, networking with professionals and peers, and hearing from people who work in the field. One student put it this way: “I think the ability to listen to people who actually work in the industry is the greatest thing the program has to offer.” Focus group input supported the survey comments, citing the opportunity to connect with and learn practical information about the nature of potential career paths from professionals through the seminar program as the most valuable part of the program.

ACCESS students also expressed high value of the practical experiences they obtained through participation in CyberWVU. Participation in the CyberWVU club was deemed to be very valuable by 87.5% of ACCESS students and somewhat not valuable by 12.5% of the ACCESS scholars. Summer internships (71.4%) and undergraduate research opportunities (57.1%) were also indicated to be “very valuable” by at least half of the ACCESS scholars. It is noteworthy, however, that internship opportunities were in the very early stages for most students at the time of this survey and may have been somewhat limited due to the COVID-19 pandemic, so it is possible they would have valued internships even more highly at the end of the summer.

Focus group participants also emphasized the benefit of the technical content they learned through the ACCESS program. As one individual explained, “I feel like I'm on a much more accelerated path than most sophomores in cybersecurity. Because at this point we haven't really taken any cyber classes, but just from what I've learned through the program and through my

research, I feel like I know a lot more than other students in my year." When the interviewer asked whether the respondent was specifically talking about content, the student continued: "We do have a good bit of seminars like, but we definitely have a lot more through the ACCESS program and, with content especially, getting a head start into using Linux and all these cyber tools that I wouldn't be learning until I was a junior or senior. I think knowing that now, it's going to help me a lot once I actually get into these classes." These comments, along with the survey data, provide evidence that the ACCESS program is providing benefits to participating students and is setting them up to stand out academically in their major or AoE. The early technical preparation may also help explain the relatively high level of confidence among ACCESS students early in their undergraduate careers. As we collect additional data from this cohort and additional cohorts, we may find additional evidence of the long-term benefits of participating in the program.

5.0 Conclusions and Future Work

Since this study is based upon the analysis of data from year 1 of a 5-year project, the population size of NSF S-STEM ACCESS scholars is small, which limits inferences. While the comparison group was large, the treatment group had only nine participants. Several interesting observations, however, can be made.

The first set of observations relate to the validation of the intentional selection bias of the ACCESS scholars. Since this group was selected from students with demonstrated financial need and with high GPAs and positive institutional engagement, it is not surprising that:

- the GPA distribution for the ACCESS scholars is much narrower than the distribution of GPAs for the much larger comparison group;
- the mean GPA for the ACCESS scholars appears to be significantly higher than for the comparison group.

Grit is associated with expected retention and persistence to graduation. While no difference between the ACCESS scholar cohort and the Complete comparison group were observed in overall Grit scores or in three of the four sub-scores, a difference was observed in the Ambition sub-score. Students participating in the ACCESS scholars program appear to have more ambition than their non-scholarship peers in cybersecurity majors or areas of emphasis. When compared to a similarly sized and "GPA-matched" comparison group of cybersecurity students, the difference in ambition appeared to evaporate; there was no significant difference in any Grit measure, including ambition, between the ACCESS scholars and the comparison group. These results may indicate that Ambition may be related to "high-achieving" students in general. Once the comparison sample was selected from a population limited to all students with a GPA of 3.3 or higher (matching the lowest ACCESS scholar GPA), the difference in ambition between that group and the ACCESS scholars was not significant.

Additionally, a large difference was observed between the ACCESS scholar cohort and the complete comparison group related to participation in professional development activities. Since these types of activities have been associated with the development of a professional identity, the difference is important. While 57% of the non-ACCESS students indicated they did not participate in any career-related extracurricular activities in the past year, all of the ACCESS scholars participated in at least one professional development activity. Across all activities, the

ACCESS students indicated higher participation than their peers in the Complete comparison group. This result may be at least partly explained by three factors: the financial support provided to the ACCESS scholars that may have reduced the time they need to spend earning money; the relatively personalized encouragement from familiar scholarship administrators; and the potentially higher ambition sub-score of ACCESS scholars which may correspond with participation in professionalizing extracurricular activities.

Combining these results, the ACCESS scholars appear to be more ambitious, earn higher GPAs and participate in more professional development activities related to cybersecurity. While these characteristics all support the expectation of increased persistence to graduation, some may be related to the selection bias of the ACCESS scholars. Future work may include using matched pairs or in other ways controlling for the GPA differences to look at the benefits of the various activities of the ACCESS program. Other characteristics between ACCESS students and their peers will be evaluated with the intent to discover the full benefits of the ACCESS program to the ACCESS students, in addition to the financial support. Since some of the ACCESS professional development activities are open to all cybersecurity students, it would be interesting to learn more about the influence these activities have on those students in the comparison group who participate in one or more of the ACCESS activities.

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