Addressing the Cybersecurity Workforce Development Problem – Augusta University's Contribution

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Abstract - When the Army Cyber Command announced that it was relocating to Fort Gordon, GA, a community based taskforce was created called The Alliance for Cybersecurity Education (ACE). ACE was founded with the following mission: 1) to facilitate the creation of a community-based cybersecurity niche to raise the effective value of 6-12 educational system and its integration into post-secondary education; and, 2) seek to increase students' capabilities, generate an employable cybersecurity workforce. Augusta University, a National Center of Academic Excellence in Cyber Defense, (CAE-CD) and also a leading organization in ACE, engaged a consortium of local public school systems, chambers of commerce, and Fort Gordon military community to develop a K-12 Career Pathway in Cybersecurity with the ultimate goal of state board approval by the GA Department of Education (GA DOE). The actual cybersecurity curriculum was written by the Cyber College, Cyber Center of Excellence, Fort Gordon. This paper presents a model for universities and public schools to collaborate on building a cybersecurity pathway in high schools by engaging local community support, using shared technology resources for students and professional development for high school teachers.

Keywords

Cyber, Cybersecurity, Cyber Defense, Center of Academic Excellence, Career Pathway, CyberSeek, U.S. Army Cyber Command (ARCYBER), CompTIA Network+, CompTIA Security+

1. INTRODUCTION

The increase in the number of data breaches reported across the United States and internationally, this increase has highlighted a growing need for skilled cybersecurity workers to protect our most important and private information in healthcare, financial, and even social media networks. For this reason, the National Initiative for Cybersecurity Education (NICE), a program of the National Institute of Standards and Technology (NIST) in the U.S. Department of Commerce introduced in 2016 an initiative that focuses on cybersecurity education, training, and workforce development called CyberSeek, which was created by CompTIA, a nonprofit trade association for IT professionals and organizations, and its partner, labor market analytics firm Burning Glass Technologies [1].

CyberSeek is an interactive online tool designed to make it easier for cybersecurity job seekers to find openings and for employers to identify the skilled workers they need across the country. This interactive tool provides a snapshot of supply and demand for cybersecurity jobs at the state and metro area levels, and can be used to grasp the talent gap facing the local cybersecurity workforce. According to CyberSeek, there are nearly 313,715 openings requesting cybersecurity-related skills across the Unites States. Of that amount, 11,377 were listed in Georgia, the eighth highest state in the country with demand for cybersecurity jobs [2]. Proficiency in cyber-security related skills are increasingly becoming a requirement for success in the 21st century economy. However, many public schools are challenged to incorporate cybersecurity skills in their high school curriculum.

This paper presents a model for universities and public schools to collaborate on building a cybersecurity pathway in high schools by engaging local community support, using shared technology resources for students and professional development for high school teachers. To put one proposed mode in context, let's first explore the Augusta, Georgia cyber ecosystem.

2. BACKGROUND

Given the cyber ecosystem developing in Augusta Georgia, the area is well positioned to make a positive contribution to solving the workforce development problem. Augusta University (AU) is co-located in Augusta, GA, with neighboring Fort Gordon, Georgia. The U.S. Army Cyber Center of Excellence, NSA Georgia, and the U.S. Army Cyber Protection Brigade are all located on Fort Gordon. Fort Gordon is also the future home of the U.S Army Cyber Command Headquarters (ARCYBER).   In December 2015, the U.S. Army announced that the U.S. Army Cyber Command would move from Fort Belvoir, VA to Fort Gordon, GA.

Ground has already been broken on the new U.S. Army Cyber Command facility on Fort Gordon and is projected to be fully operational by 2020. Augusta University salutes the Army's approach in bringing cyber education assets and joint cyber operational forces together in one location.   With the Army's organization initiative, the operational tip of the spear will more effectively inform needed cyber education adjustments to quickly update operational cyber skill sets. The relocation of ARCYBR does require a massive effort to improve the quality and availability of a cyber-workforce in our immediate area. As the local university, AU is doing everything we can to develop and expand our region's cyber workforce.

In April 2016, the National Security Agency (NSA) and the Department of Homeland Security (DHS) designated Augusta University as a National Center of Academic Excellence in Cyber Defense (CAE-CD) Education through the Academic Year 2021. Less than two years later, Augusta created a new School of Computer and Cyber Sciences bringing our computer science, IT, cybersecurity and engineering curriculum under one school, and AU has embarked on an ambitious, multi-year effort to significantly expand our computing, cybersecurity, and data science graduate and research activities.

With the announcement of ARCYBER relocating to Fort Gordon, GA, the Command began to work with the local community to help highlight the need to improve the quality and depth of technology education in our school systems to help meet future ARCYBER cybersecurity workforce education in our area.

In response to ARCYBER's stated needs, a community based taskforce name The Alliance for Cybersecurity Education (ACE) was created. ACE was founded with the following mission: 1) to facilitate the creation of a community-based cybersecurity niche to raise the effective value of 6-12 educational system and its integration into post-secondary education; and, 2) seek to increase are students' capabilities, generate an employable cybersecurity workforce, and position the Central Savannah River Area (CSRA)/Fort Gordon Cyber District as a resource and partner to NSA Georgia and the Cyber Center of Excellence, Fort Gordon in cybersecurity expertise. Let's next examine the K-12 cyber curriculum development under the ACE's leadership.

3. K-12 CURRICULUM DEVELOPMENT

Augusta University was a leading organization in the formation of ACE and includes representatives from Augusta University, Augusta Technical College, Richmond/Columbia County Boards of Education, and rural schools in Burke, McDuffie, and Lincoln rural counties, and Chambers of Commerce from Richmond and Columbia Counties.

ACE's primary mission was to develop a defined curriculum related to cybersecurity for grades 9-12 and to create a pipeline through post-secondary education and final employment. ACE successfully brought together two different Georgia County School Systems and County Chambers of Commerce to work together and develop a cybersecurity curriculum pathway for Georgia High Schools. The actual cybersecurity curriculum was written by the Cyber College, Cyber Center of Excellence, Fort Gordon and is in essence topics and student learning objectives found as part of CompTIA Network+ and CompTIA Security+ training. This cybersecurity training was added to an already existing 9th grade technology course entitled "Introduction to Digital Technology". CompTIA Network+ and Security+ curriculum serves as the basis for a 10th grade "Introduction to Cybersecurity" and an 11th Grade "Advanced Cybersecurity".

All three courses were used to create a cybersecurity curriculum

pathway that was approved by the Georgia Department of Education (GA DOE) in spring 2015 for use by all Georgia High Schools statewide. GA DOE provides a full description of the Cybersecurity (curriculum) pathway on-line [3]. The fact that the state of Georgia created K-12 cybersecurity standards in 2015 is a remarkable feat considering many cybersecurity advanced states are only now beginning to develop statewide cybersecurity curriculum standards (Maryland and North Carolina previewed their efforts during the NICE K-12 Conference in December 2018) [5,6]. The Georgia Department of Education (GA DOE) Cybersecurity Pathway utilizes the National Initiative for Cybersecurity Education (NICE) Cybersecurity Workforce Framework. Augusta University uses the NICE Cybersecurity topics as a guide for the NDG's Model for supporting K-12 Cyber, which is listed below in Table 1.

Table 1 NICE Framework GDOE Cybersecurity Pathway Targets				
Securely Provision	**Operate & Maintain**	**Oversight & Development**	**Protect & Defend**	**Investigate**
• Software Assurance • Systems Security Achitecture	• Systems Security Analysis	• Info Security Operations	• Computer Net Defense Analysis • Incident Response • CND Infrastructure Response • Vulnerability Assessment & Mgmt	• Digital Forensics

The Cybersecurity (curriculum pathway) was piloted by six different high schools in the local area fall 2015 with different levels of success due to the following challenges: 1) no high school teacher professional development was created to assist current high school teachers to teach

this new curriculum and 2) appropriate technology resources (i.e., an isolated network student lab environment) were not identified to support the cybersecurity curriculum.

4. AU's MODEL FOR SUPPORTING K-12 CYBER

With AU's strategic vision to grow in all areas of cyber education, a state-of-the art 1600 square foot cyber lab environment was designed to improve students' ability to create, experiment with, attack and defend networks. Augusta University committed a $2.5M investment, and is the only university in the state of Georgia to have a lab facility specifically designed for collaborative cyber education.

The GA DOE cybersecurity pathway is based on professional cybersecurity professional certification training that represents core knowledge needed by anyone seeking to enter the cybersecurity field including high school students. The GA DOE cybersecurity pathway is excellent, but the success of this pathway has been hindered by the lack of qualified high school teachers to teach the required curriculum and the lack of sand-boxed virtual network access for student hands-on learning, experimentation and exploration. Cybersecurity education and training by the nature of the hands-on skills must be developed and should be performed on an isolated, sandboxed network. The opportunity for most school systems to afford a computer lab; yet, one that is totally isolated from the school's network infrastructure, is formidable.

It is not typical for a university to support high school academics. The need to expand the nation's cyber workforce is so critical, AU, as a Center of Academic Excellence in Cyber Defense (CAE- CD), chose to think outside the box and innovate to help drive quicker cyber workforce development. Augusta University took action to support and help our local high schools piloting the GA DOE Cybersecurity (curriculum) pathway by first conducting Network+ and Security+ training at no cost as a professional development activity for all high school teachers involved in providing the GA DOE Cybersecurity (curriculum) pathway. We followed this initiative by allowing remote high school student access to AU's virtual cyber lab.

The AU cyber lab is based on NETLAB+, a remote access solution developed by Network Development Group (NDG) that allows academic institutions the ability to host virtualized IT equipment, virtual machines, and custom courseware [6]. Listed in Figure 1 is a diagram of the NDG network infrastructure. Augusta University provided access to the local high schools for the NDG hosted lab courses: NDG Security+, NISGTC Network+, and NISGTC Linux+. Augusta University also developed an on-line "Introduction to Networking" and "Introduction to Cybersecurity" courses of instruction with embedded NDG labs that was offered to any high school offering the GA DOE cybersecurity (curriculum) pathway to help augment teacher preparation and support in class curriculum presentation. A Memorandum of Understanding with the Local Boards of Education was developed to offer remote lab access to self-selected high schools, and the use of a white hat agreements for students to gain access to Au's virtual labs impacting the K-12 pipeline for cybersecurity education.
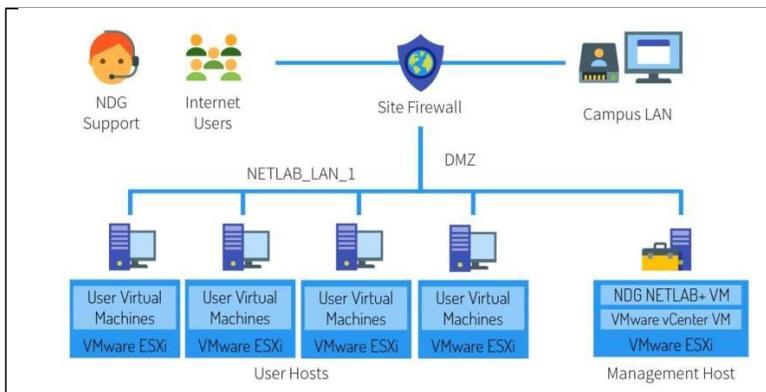

Figure 1: NDG Infrastructure.

4.1 NDG Security+

In this module, students gain hands-on practice in the skills needed to secure a network, which aligns with CompTIA Security+ Certification. The content includes seven virtual machines and 25 lab exercises. Figure 2 depicts the NDG Security+ network.
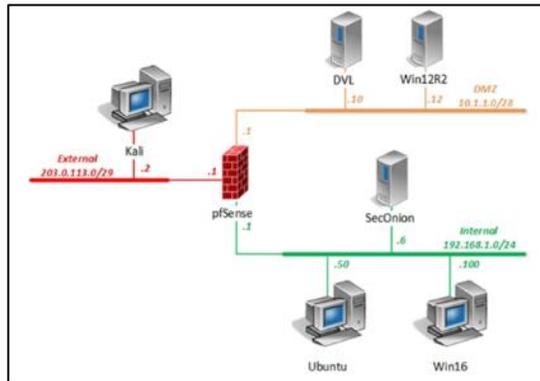

Figure 2: NDG Security+ Network.

4.2 NISGTC Linux+

In this module, students gain hands-on practice in the skills needed to configure, manage, and troubleshoot Linux systems, which aligns with CompTIA Linux+ Certification (LPIC-1). The content includes four virtual machines and 22 lab exercises. Figure 3 depicts the NDGTC Linux+ network.
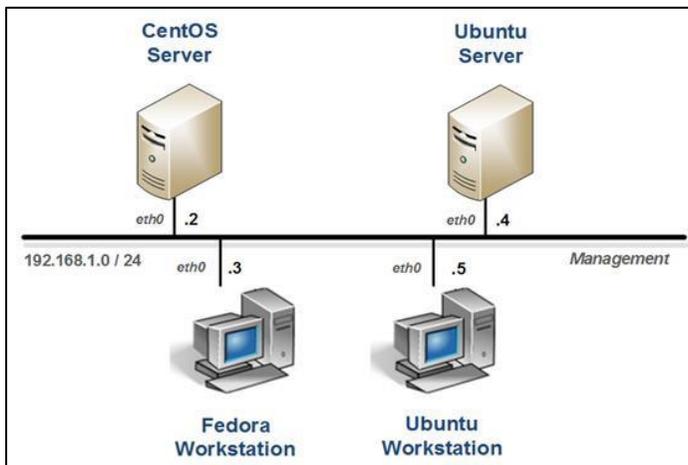

Figure 3: NISGTC Linux+ Network.

4.3 NISGTC Network+

In this module, student learn key skills to troubleshoot configure, and manage a network, which aligns with CompTIA Network+ Certification. The content includes five virtual machines and 12 lab exercises. Figure 4 depicts the NISGTC Network+ network.
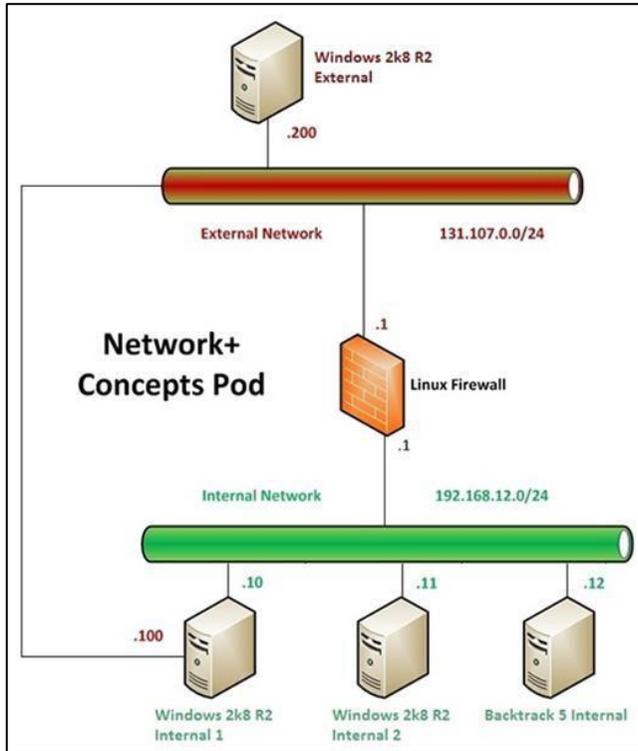

Figure 4: NISGTC Network+ Network.

4.4 Impact

Augusta University provided shared resources from its cyber-lab for three area high schools. This was the first pilot utilizing NDG NETLAB+ to supplement the "Introduction to Cybersecurity" pathway with virtual lab activities for these three high schools. Augusta University provided free access to these three high schools, then offered additional high schools in years two and three with the following impact: 127 students used our virtual cyber lab for their hands on cybersecurity lab experience in spring 2017. By

fall 2017, a fourth high school was added and demand had increased with serving 307 students. By fall 2018, two high schools and a middle school were added via a local grant program and demand had topped over 450 students. Augusta University also developed an on-line "Introduction to Networking" and "Introduction to Cybersecurity" courses of instruction with embedded NETLAB+ labs that is also offered to any high school teaching the GA DOE cybersecurity (curriculum) pathway for free to help augment teacher preparation and support in class curriculum presentation. Information about this K-12 Initiative was shared and presented at the 2017 & 2018 NICE K-12 Conference and through the Southern Regional Education Board (SREB) organization [7,8,9,10].

5. NEXT STEPS

While Augusta University has been instrumental in helping high schools develop the cybersecurity curriculum, providing professional teacher development for teachers teaching the cybersecurity career pathway, AU will continue to provide remote access to our cyber lab as grant funds are available for additional high schools in the Fort Gordon Cyber District. The next steps are to develop a computer science endorsement for K-12 teachers that includes cybersecurity focus areas.

According to Michael Brown, then CEO at Symantec [11], and the recent International Information System Security Certification Consortium ((ISC)²) Global Information Security Workforce Study [12], there is a projected shortfall of 1.5 million cybersecurity professionals over the next five years. In addition to a projected shortfall of professionals is also a decrease of high schools offering computer science or cybersecurity as part of an advanced rigorous curriculum. The percentage of U.S. high school students taking STEM courses has increased over the last 20 years across STEM disciplines, except for computer science where it dropped from 25% to 19% [13]. According to the CollegeBoard, which tracks advanced placement (AP) exams by state, 2,033 Georgia students took the AP computer science exam in 2016. By comparison, about 11,532 Georgia students took AP U.S. history, 16,551 took world history, and 18,862 students took English language. Of the 2,033 Georgia students who took the AP computer science exam, only 47.5% had a

passing score of 3 or higher. For South Carolina (SC), 374 SC students took the AP computer science exam in 2016. By comparison, about 5,973 SC students took AP U.S. history, 5,032 took English literature, and 6,617 SC students took English language. One assumption that can perhaps be made from the information above is that there are not enough qualified teachers nationally and/or within the state of Georgia that are prepared to teach AP computer science.

In June 2017, the Georgia Professional Standards Commission (GAPSC) approved Rule 505.3.86 – Computer Science Endorsement Program to address the gap in K-12 preparation for computer science. This rule states the field-specific content standards and requirements for approving endorsement programs that prepare individuals to teach computer science in grades PK-12. A GAPSC approved educator preparation provider, like Augusta University, is required to seek state approval to offer this field as either a stand-alone endorsement program or as an endorsement program embedded in a GAPSC-approved initial preparation program or an advanced degree-only preparation program. The GAPSC also requires that educator program providers address the ten standards adapted from the Standards for Computer Science Educators published in 2011 by the International Society for Technology Education (ISTE), and the Computer Science Teachers Association Interim Standards published in 2016 [14].

Currently, Augusta University is creating a nine-hour graduate level Computer Science endorsement program that includes a strong focus in cybersecurity. This endorsement program will accommodate a traditional three credit-hour delivery for on campus students, but will also include a parallel, on-line course. The on-line format will serve several purposes: 1) it will allow students in the traditional format to view material and complete assignments without penalty on-line in the event a student misses a class; and 2) development of the on-line curriculum will allow the courses to be easily structured into a stand-alone, fully on-line component. This on-line component will cater to teachers who are not in the Fort Gordon Cyber District, with potential national reach.

6. SUMMARY

In this paper, we described how to build a K-12 Career Pathway in Cyber using consensus among community partners in support of cyber education as identified by Augusta University's experience with the formation of Alliance for Cyber Education (CAE), a consortium of local public school systems, chambers of commerce, and military community on Fort Gordon military base. The K-12 Career Pathway in Cyber once created and approved by the Georgia State Board of Education, posed a challenge to public school systems in providing network capacity for virtual labs, but also the challenge of finding qualified teachers to teach cybersecurity pathway courses. Successful engagement with cybersecurity education requires not just technical competencies in areas such as coding, networking, and hardware, but also an understanding of the relevant pedagogy to teach cybersecurity content. It is not typical for a university to support high school academic programs, but cybersecurity is a major risk to our local, state, national, and global economies. By preparing high school students for post-secondary and the workforce, universities and public schools can collaborate to close the cybersecurity workforce gap.

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