



## **No-Cost Implementation of Network Security Labs Utilizing AWS Educate in an Undergraduate Fundamental Network Security Course**

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by

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### Abstract

In our Fundamentals of Network Security course, we had traditionally used a campus hardware environment and virtual machines. Students would complete their network security labs utilizing this equipment either on-site or remotely. However, many students expressed frustration to this routine, part of the reason being lag in system performance. In response, we considered a no-cost program through Amazon called Amazon Web Services (AWS) Educate. This program allows virtual classrooms to be created. For this course, these classrooms were a gateway that students utilized to create and work with various Operating System Instances. This case study examines an online laboratory environment used in a fundamentals of network security course that covers the competencies of the CompTIA Security+ certification. The main objectives were to explore the feasibility of utilizing the no-cost AWS Educate program, determine students' opinions on utilizing AWS and to determine the pros and cons of students utilizing AWS for labs and assessment. In addition, a comparison of student grades and lab completions was examined with five sections of the course. Two sections used the traditional campus hardware lab scenario. Three sections utilized AWS Educate to complete the labs. This study was based on analysis of responses to an end-of-semester survey, comparison of grades and completeness of labs attempted in each format, students' suggestions for lab improvements with AWS, and student comments and reactions to utilizing AWS. The advantages and challenges of accessing and utilizing AWS Educate for network security labs will be examined, including student assessment, and a list of suggested best practices for students and instructors utilizing AWS Educate for labs for will be given.

### No-Cost Implementation of Network Security Labs Utilizing AWS Educate

This study evaluates student experiences using the AWS Educate program to access resources available in the Elastic Compute Cloud (EC2). The Fundamentals of Network Security course is delivered face-to-face (F2F) and via Distance education (DE). This course prepares sophomore students to take the CompTIA Security + exam. Ensuring that program resources are available 24/7 is considered a necessity to most students. Regardless of students' location, expectations regarding connectivity are the same (Pullen, 2010). Saliyah-Hassane, Saad, Ofofu, Djibo, Mayaki, and Amadou (2011) completed a study showing their virtual lab environment based on the concept of software as a service. This allowed students to access their lab environment remotely.

The results of this study show student preferences to using AWS EC2 to complete Security+ labs due to availability (regardless of student location), speed and resource utilization. AWS Educate is a free service provided by Amazon that allocates credits to students, teachers and researchers. This program is used in more than 200 countries by approximately 2,400 educational institutions (AWS Educate, 2020). An instructor will request a course be setup within AWS Educate. The instructor shares the topic and requests a certain amount of credits for the course. Currently, \$100 is the standard set of credits awarded. More can be requested with justification. In this course, via free AWS Educate accounts, students accessed AWS EC2 to launch and manage various server instances of operating systems. A goal of this study is to eliminate the need for university acquisition of facilities and local laboratories to host, manage and maintain the environment, while at the same time providing easy access to necessary lab equipment 24/7. Omar and Lunsford (2017) conducted a study to measure the students' satisfaction level, their ability to learn from the lab exercises, the quality of the lab materials,

availability of technical resources and did an analysis of discussion board threads (questions posed by students) who were utilizing virtualized equipment in a fundamental network security course. Students who earned a C or better were satisfied with the lab design and setup. Li, Jones, and Augustus (2011) evaluated different virtualization environments for labs and determined that a “centralized approach is especially useful in online labs which require high-end resources, support a large number of users, and provide rapidly changing contents. It helps create a digital learning environment for students to study from any place and at any time” (p.12).

A case study is used to investigate the advantages, challenges and issues students may experience using AWS EC2. A survey is conducted to measure the students’ satisfaction level with AWS, the performance of AWS, and support provided. The remainder of the paper is organized as follows: the background section includes information about the lab model including lab design, lab components, and lab supports used. The following section discusses the evaluation methodology. The decision and results section include an analysis of the student survey, and feed-back regarding student lab experiences during the course. The final section of the study discusses the conclusions that are drawn.

## **Background**

### **Lab Model**

In this section the lab design, lab manual exercises, instructions and lab template will be presented to show the structure of the lab.

**Lab Design.** The lab consists of four main components that are discussed in detail in this section.

The main components of the lab are:

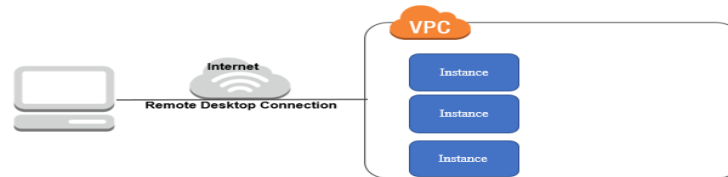
1. The lab manual utilized in this course is the Security+ Guide to Network Security Fundamentals 6<sup>th</sup> edition by Andrew Herd.

2. The lab configuration utilized in this course includes AWS instances in EC2 accessed through AWS Educate. These instances are setup by the individual students. VirtualBox was also utilized for some labs requiring desktop operating systems such as Windows 10 and Kali Linux. (Note: A Kali Linux Amazon Machine Image free tier wasn't available via AWS EC2 during the delivery of this course. Therefore, VirtualBox was utilized)
3. The lab templates utilized in this course provided a way for students to showcase their work and demonstrate understanding of the labs.
4. The lab supports utilized in this course were provided to help students as they perform the labs.

**Lab Configuration.** In order to provide the students with the necessary resources to perform the required labs in the lab manual, instances are created in AWS EC2 and virtual machines are created in VirtualBox by students. East Carolina University is located in Greenville, NC. It serves approximately 23,000 students annually. This course is part of the Information and Computer Technology Degree programs within the Department of Technology Systems and the School of Engineering and Technology.

Figure 1: Lab Structure shows the structure of the lab environment in AWS EC2 used by both DE and F2F students at East Carolina University to support the Fundamentals of network security course. East Carolina University is located in Greenville, NC. It serves approximately 23,000 students annually. This course is part of the Information and Computer Technology Degree programs within the Department of Technology Systems and the School of Engineering and Technology.

Figure 1: Lab Structure



Students created and accessed Windows Server 2016 and Windows Server 2012 instances via AWS EC2. In addition, students utilized VirtualBox on their local personal computer to create and work within Windows 10 and Kali Linux.

**Lab Template.** The lab manual walks the students through the different lab steps. In addition, a lab template is prepared by the instructor. This template is where students document their lab work and provide evidence of understanding. Each of the 4 templates group multiple labs together from the 60 required lab exercises. Students are required to answer the questions and record screen captures of lab work in the templates and submit the completed templates as assignments to the learning management system. During each lab, students are asked to take screen captures of their work within AWS EC2 or VirtualBox and answer questions after finishing several lab steps. The student answers are then evaluated by the instructor and students are provided feed-back regarding their work.

**Lab Supports.** In order to support the students, various types of supports are provided to help the students perform the labs. Both F2F and DE students are supported through asynchronous discussion boards in Blackboard and synchronous webinars using WebEx. Usually, only F2F students are supported through F2F lab help sessions unless a DE student decides to commute to

campus. However, DE students can access help via the lab sessions through WebEx which is available during the same time as open lab hours.

**Lab sessions and WebEx meetings.** According to recent research, webinars are positively connected with improvements in knowledge and skills (Gegenfurtner, 2019). Each week in the semester, two lab help sessions are offered in the evenings and once on Saturdays. These sessions are available both in a F2F format and via WebEx. The instructor or lab tutor leading the help session uses an open classroom, but also logs into WebEx. Every student at the University has free access to WebEx. Therefore, both F2F students and online students can join the discussion and ask questions. Students in the F2F lecture also have the option of using WebEx webinars to attend the help sessions. Lab tutors are undergraduate student workers paid by the department to provide lab support and tutoring for undergraduate students. Students attending the sessions can interact directly with instructors and lab tutors to discuss issues and ask questions related to their lab. In addition, they can obtain help with their own computers as well. Each session runs for 4 hours and questions are addressed to resolve any student issues.

**Discussion boards and email.** It is believed that through DE, online discussions have the potential to improve students' critical thinking and problem solving (Zalpaska, Falnegin, & Rudd, 2004). Discussion boards are one of the most frequently used settings for online discussion. Data suggests that students perform better in learning settings where a mixture of classroom and online technologies is employed and there is no deterioration in the interest on the topic (Seethamraju, 2014). Due to time limitations for some F2F and DE students, a second support option through asynchronous discussion boards is also provided. A discussion board is available around the clock for students to seek assistance or share how they resolved an issue or problem. The discussion board utilized in this course is designed as a collaborative threaded



response system provided by the Blackboard LMS and is supervised by the instructors and the lab tutors. Students can interact with each other, instructors, and lab tutors using the discussion threads. When a student has an initial problem, they are expected to first search the discussion threads to see if the solution may already be posted. In addition, students can also email their instructor or lab tutors to ask questions confidentially.

### **Evaluation and Analysis**

In order to evaluate the performance and benefits of the labs completed in AWS EC2, a three facets evaluation model is applied to study the experiences students had while completing the labs. The three facets addressing the lab challenges are system, support, and course. The system refers to the infrastructure which includes the AWS EC2 instances and VirtualBox utilization on their personal devices. The support refers to the opportunities students utilize to receive help. The course refers to the challenges and benefits students experienced with the instructional material.

**System Challenges.** In order to evaluate the effectiveness of the labs and student satisfaction with the labs, a student survey was administered. The survey consists of 11 questions aimed at evaluating these three areas. The survey was administered online and accessed via their Blackboard course. The survey was voluntary and anonymous. However, if 90% of students completed the survey, the entire class would receive extra credit. Some questions were presented as open-ended questions. For the questions that used Likert scale, the following five levels are used: Definitely yes, Probably yes, Somewhat, Probably not, Definitely not.

System challenges investigated are ease of use and availability of AWS EC2 used by the students, as well as, what they liked and disliked about it. They were asked to compare their

experiences using AWS to when they use VirtualBox. The following questions are answered by students via the survey:

1. Did you find AWS easy to use?
2. Did you find the availability of the AWS EC2 platform ideal for completing your labs?
3. What did you like most about AWS?
4. What did you like least about AWS?
5. Which product do you prefer: AWS or VirtualBox and why?
6. When using AWS did you have any issues? If so, what were they?

**Support Challenges.** To determine if lab support was needed and if the support was effective, students were asked the following questions:

7. Did you find the support for the course labs sufficient? (this includes Discussion board, open lab time/meetings, and WebEx webinars)
8. What additional material and support would you find beneficial to help you succeed in this course?

**Course Challenges.** Students were asked about their understanding of the course material, what challenges they faced and what they felt worked well.

9. The labs were beneficial to my understanding of the Security+ material
10. What did you think worked best in the course regarding course material and instruction?
11. What were your biggest challenges with the course material and instruction?

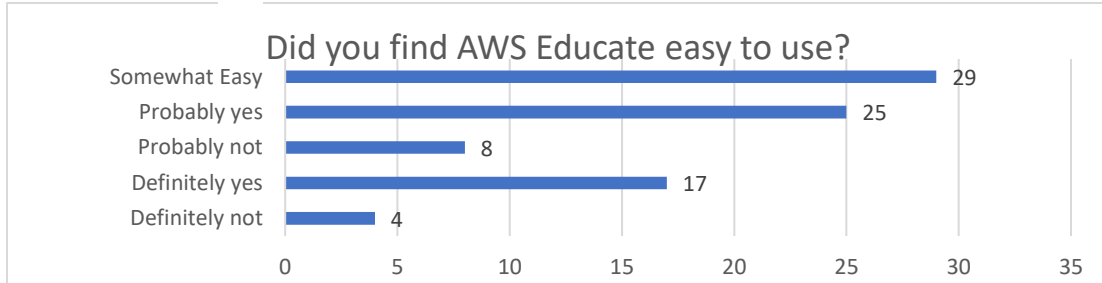
### **Discussions and Results**

The student survey results are presented in this section. The effectiveness of the lab is evaluated and recommendations for future improvements are suggested. As previously mentioned, the student survey focuses on three facets of the lab environment. The results and findings from surveying 83 students who utilized AWS EC2 to complete the course labs are analyzed and discussed.

### **Lab System**

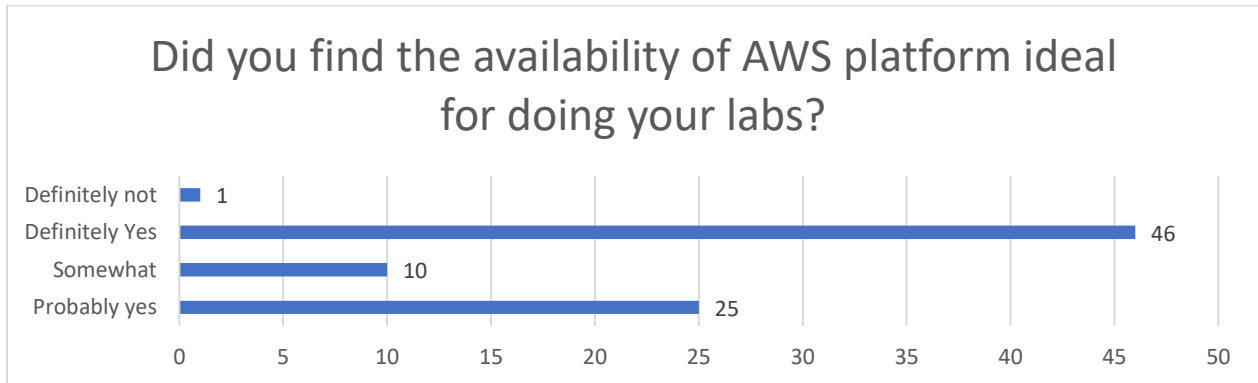
The results in figure 2, show the response of the students regarding the ease of use of the lab environment. The vertical axis represents the average Likert scale value chosen. Most of the students agreed (85%) that the AWS lab environment was is easy to use.

Figure 2: Did Students find AWS easy to use?



Eighty-one students (98%) shared that the availability of the AWS EC2 was an ideal platform to completing labs at any time they chose. Lab availability can be a problem on campus due to lab utilization by other classes and student schedules. In addition, utilizing lab equipment that is on campus, by remote DE students can be extremely slow depending on how many other students are utilizing the system. Students didn't experience those issues using AWS EC2.

Figure 3: Did students find the availability of the AWS platform ideal for completing their labs?



Students were asked via an open-ended question, what they liked most about AWS EC2.

Eleven students (13%) specifically mentioned the availability of the resources. Twenty-three

students (28%) mentioned easy access and 16 students (19%) mentioned speed. Six students (7%) referenced how much they appreciated using AWS EC2 resources versus utilizing resources on their local machine.

Students also shared what they liked least about AWS EC2. The free tier students utilized to complete their labs could occasionally operate slowly or not as fast as they preferred. Fifteen students (18%) referenced some lag while completing the labs. Twenty-three students (27%) shared that the navigation was difficult or that the site was not intuitive. Three students (4%) shared that they worried about using all of their free credits due to the amount of time it took them to complete the labs. It should be noted, that students can request an additional one-time allocation of free credits if they run out during the class.

Students responded to a question about whether they preferred VirtualBox or AWS EC2 and why. Forty-four students (54%) preferred using AWS EC2 over VirtualBox. Twenty-eight students (34%) shared that they preferred to use VirtualBox instead of AWS. Eleven students (12%) didn't have a preference on using one over the other. Students also responded to an open-ended question regarding what they liked and/or disliked about VirtualBox when compared to AWS EC2. Five students (6%) referenced that using AWS EC2 resources versus their computers resources was a huge benefit. Six students (7%) also referenced that VirtualBox was easier to setup and deploy a virtual machine than AWS EC2 instances. Two students mentioned that VirtualBox was more intuitive than AWS EC2 to create machines.

Students were asked what issues they experienced when using AWS EC2 instances for labs. Students shared various issues. Two students (2%) mentioned instances disappearing from their account. It should be noted that instances can be stopped or terminated. Sometimes students

confuse the two and end up deleting their instance. Three students (4%) mentioned slow speeds during various labs. Specifically, one student shared that the free resources allocated were not fast enough. Three students (4%) mentioned having difficulty with utilizing remote desktop with AWS EC2. One student mentioned an account access issue that was experienced.

### **Lab Support**

Sixty-seven students (80%) shared that support for the labs was sufficient. Support was provided via F2F lab sessions, WebEx webinars, discussion board postings, email, and phone discussions. Students had varying comments on which support they preferred. Students shared that they equally found the discussion threads and open lab support helpful. Eight students (10%) did not utilize any of the support services and didn't suggest anything in addition to what was offered. Two students (2%) shared that additional open lab times would have been beneficial because they were working when lab hours were available. Students were asked what additional support they would find beneficial to help them succeed in the course. Four students (5%) shared more detailed instruction was needed on accessing and utilizing AWS EC2 instances. Two students (2%) shared that providing more video instruction would be beneficial

### **Lab Course**

The role of the labs in students understanding the course material was also evaluated by the survey. Sixty-five students (78%) responded that the labs completed via AWS EC2 were beneficial to their learning. Eight students (10%) mentioned more labs to complete would help them. It was specifically suggested by three students (4%) that labs be due weekly instead of once a month. One student explained that they felt they could digest and retain the information better. One student shared additional test banks to prepare for the Security+ exam was needed.

Students were asked an open-ended question about what they think worked best in the course. Nine students (11%) mentioned completing the labs in some form helped them learn the material. Two students (2%) shared specifically that AWS EC2 was a great option instead of using VirtualBox or another product. Two students (2%) shared that they felt the course prepared them for the Security+ exam.

Students were then asked an open-ended question about what they liked least in the course. Answers varied. One student referenced that the reading was excessive. Six students (7%) mentioned having to use two systems (AWS EC2 and VirtualBox) was too much. One student felt that there were too many labs. There was not a theme or multiple items shared by students regarding this question. Some students did not answer this question.

When comparing grades and lab completeness of students in the AWS sections versus students who utilized the on-campus lab equipment, there was not a significant difference. However, slightly more than half of the students who didn't utilize AWS were frustrated with the speed of the on-campus equipment. Those same students were also unsatisfied with the availability of the lab equipment. Students in sections that utilized the on-campus equipment shared that many times they waited until the day the lab was due to begin working with the equipment. Large numbers of students accessing the on-campus equipment caused significant lag times. Students who worked ahead didn't experience the same lag times and didn't report frustration with using the on-campus equipment. A significant benefit of using AWS EC2 is that students can work on their labs in large numbers and performance will not be affected. Another significant, was a reduction in questions from students regarding the labs. Students who utilized

AWS EC2 reached out significantly less (52% reduction in questions) than those whose used the on-campus equipment. When examining the questions submitted by students, they asked for more time extensions when using on-campus equipment. They also experienced more technical issues.

### **Conclusions**

The student opinions of using AWS EC2 to complete labs and support provided specific to a sophomore level networking security laboratory-based course were reviewed. A lab evaluation model classifying the evaluation of three facets of the student perspective was shared. The three facets are system, support, and course. These facets were used to classify the assessment of the student experiences. Both the availability of synchronous support through face-to-face and virtual webinars, and the asynchronous support through discussion board support were useful to the students. Students slightly preferred using AWS EC2 versus VirtualBox. Students preferred ease of access and availability of AWS EC2. Students reached out less with technical questions using AWS EC2 than on-campus equipment. In addition, there was no significant difference in final grades of students who utilized on campus lab equipment versus students who used AWS. Students shared that additional video tutorials and additional labs would be helpful to understanding and learning of the Security+. Students also shared that having labs due more frequently would benefit their learning. Students also shared that additional detailed directions, to include a video, would be helpful for initially accessing AWS EC2 resources. Further studies can examine the impact these additions would have on their perceptions of the course.





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