Integrating AWS Cloud Practitioner Certification into a Systems Administration Course

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Abstract

Cloud computing has grown to become an integral part of information technology (IT) infrastructure. Organizations are increasingly utilizing cloud services to deliver a variety of applications and services in conjunction with their on-premise data center environments. As such, students pursuing careers in information systems and computing need to add cloud concepts and skills to their "tool belts" to meet the demands of employers. Amazon Web Services (AWS) has the largest market share of cloud providers. This paper reports on a systems administration course at a private liberal arts institution that was re-tooled to integrate cloud computing fundamentals using AWS as a platform for hands-on labs. Cloud computing concepts paralleled content for the AWS Cloud Practitioner Certification Exam, which students took at the end of the course. The course provided necessary skills for students in their development as information systems (IS) professionals, as well as important lessons for IS and computing educators as they consider how to incorporate cloud computing skills into their curricula.

Keywords: cloud, computing education, certification, pedagogy, amazon web service, AWS

1. INTRODUCTION

The information technology (IT) industry has seen considerable growth in the use of cloud-enabled services, or those applications and services that are not within the confines of the traditional on-premise data center. Organizations recognize the advantages of having a flexible architecture that allows them to scale up or down as needed, to pay for compute, memory, and storage as a utility, and to provide for business continuity and disaster recovery in the event of service disruption. According to a white paper from IDC, 85% of enterprises will incorporate some combination of public, private, community, or hosted clouds into their environment (Anderson, 2017). The biggest players in the cloud space include Amazon Web Services (AWS), Microsoft Azure, and Google Cloud Platform (GCP). Among these three, AWS has become the leader based on market share (Richter, 2021). AWS provides a complete suite of tools to launch server and serverless compute resources, file and blob storage systems, and fully managed databases, in addition to emerging technologies like artificial intelligence, quantum computing, and the Internet of Things (IoT).

A faculty member from the IS department within the business school collaborated with a recent alumni and systems analyst to redesign a systems administration course to focus on learning outcomes around platform-agnostic cloud computing concepts, build hands-on skills related to cloud, and to incorporate an industry recognized certification exam. The redesign of the course prioritized teaching students cloud concepts with a vendor-agnostic approach. However, learning about cloud computing is only one part of the equation. Students are more prepared for their careers when they have an opportunity to hone their craft in an applied fashion and receive validation from third-party stakeholders (Podeschi, 2016). Using this approach, the course incorporated several hands-on labs using AWS labs and tutorials. The course culminated with students taking the AWS Cloud Practitioner Certification (CLF-C01) exam.

This work builds upon previous research by Woods (2018), where cloud skills were successfully built into an introductory IT course. Specifically, this paper incorporates similar lab assignments alongside cloud concepts with the addition of the AWS Cloud Practitioner Certification exam. This paper first reviews the available literature related to the growth and use of cloud providers across the market in addition to previous research done on integrating cloud computing into the classroom. Course design is then outlined along with the results of a student questionnaire, summaries from lab assessment rubrics and student feedback from reflections, and results of the AWS Cloud Practitioner Certification exam. The paper concludes with a discussion on considerations for future courses and how the course can be improved upon. This research focuses on the design and implementation of the first iteration of incorporating cloud technology into the IS curriculum of a private 4-year university. The lessons learned in this class will serve as a guide for other classes within the major, and to other educators looking to enrich their courses. This work is important to information systems and computing educators so they can continue to evolve their respective curricula to meet the expectations of the industry.

2. REVIEW OF LITERATURE

The idea of cloud computing is not a new concept. Since the 1990s, users have been accessing computing resources that are not located on-premises, or within the walls of the organization. Consumers have also been accustomed to using Software-as-a-Service (SaaS) platforms for email through providers such as Gmail. To the layperson, cloud computing is simply the use of computing resources on another computer. However, the term "cloud computing" did not enter the commercial arena until 2006 when Amazon launched its Elastic Compute Cloud (EC2) service. These services transformed computing into a utility where companies could lease processing power, memory, and storage on a monthly basis (Erl, Mahmood, & Puttini, 2013, p. 27). Cloud computing as an IT strategy is a stark contrast from the traditional data centers located within the walls of an organization's corporate headquarters.

Organizations are making the case for shifting their IT services from on-premises (also known as private cloud) to hybrid or public cloud infrastructure. From a financial perspective, capital expenditures and depreciating assets are shifted to expense items on the balance sheet and income statement. Cloud computing offers scalability for organizations to be able to add compute, memory, and storage almost instantly. Much of this advancement is driven by virtualization technology and the ability to automate the provisioning of computing resources. In addition, cloud computing offers resiliency and ensures business continuity by using replication across geographically disparate data centers. (Erl, Mahmood, & Puttini, 2013, p. 28-30). These capabilities have allowed organizations to shorten the software development life cycle and increase service uptime.

Cloud computing can be broken up into three main delivery models: Software-as-a-Service (SaaS), Platform-as-a-Service (PaaS), and Infrastructure-as-a-Service (IaaS). SaaS typically only allows access to the front-end user interface, often through a web client. Application updates are applied by the vendor, and the customer has controlled choices regarding configuration settings. Products like Salesforce, Slack, and Gmail are examples of SaaS. PaaS allows some administrative control over IT resources. For example, the server operating system and established software packages may be pre-installed for the user to customize and configure. Some web hosting providers fit into this category. IaaS allows full administrative access to the virtualized infrastructure. The cloud vendor provides access to network, server space, and tools for provisioning virtual machines, configuring network, security, and applications. Vendors like AWS, Google Cloud, and Microsoft Azure are the three largest IaaS and PaaS providers in this space with a combined 61% of market share as of the end of 2020 as seen in Figure 1 (Richter, 2021).

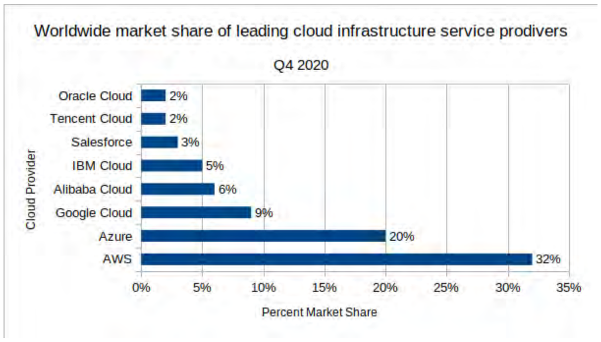

Figure 1: Cloud Market Share (Richter, 2021)

Employer Needs

With the ever-increasing push to move technology to the cloud, organizations are quickly realizing the need for cloud engineering skill sets. The Global Knowledge IT Skills and Salary Survey is an industry examination of skill needs and salary potentials for those skill sets formed from responses of IT professionals around the world. According to the 2020 report based on this survey, which produced 9,505 responses, cloud computing is the second most challenging area for organizations to find talent and the second highest invested skill area, only behind cybersecurity (Global Knowledge, 2020).

As the need for these specialized skill sets becomes apparent, talent acquisition strategies are relying more on industry credentials to quickly identify ideal candidates. Platforms like LinkedIn and vendor specific job boards, where certifications become gatekeepers for ranking high in search algorithms, have also largely contributed to the need for industry credentials. Even IT hiring-managers who are focused on "relevant skills" for a job say that certifications can serve as a distinguishing factor and pave the way for higher paying jobs and promotional opportunities (Global Knowledge, 2020). Research conducted by Gomillion (2017) concluded that while it was difficult to ascertain the value of one certification over another, obtaining an industry-recognized certification prior to graduation signaled the ability of a student to continue learning outside of class.

Furthermore, employers are looking for students who have real-world experience that extends beyond the typical classroom (Chuang & Chen, 2013). IS educators are continually looking for ways for students to build their resumé while they are pursuing their respective majors. This increases their marketability while applying for internships and pursuing full-time positions as students get closer to graduation. Several examples exist of previous research by IS educators espousing the success and value of integrating real-world projects into IS courses (Abrahams, 2010; Podeschi, 2016; Saulnier, 2005; Vaz & Quinn, 2014). These examples mostly manifest themselves as client consulting projects or assistance with not-for-profit organizations as service-learning opportunities. One unique way of identifying "resumé building" activities for students is through a broader concept using a third-party stakeholder. In the example provided by Podeschi (2016), a third-party stakeholder such as a business, panel of experts, or client evaluates the students' work rather than the professor, known as performance learning. In the case of passing a technical certification, that organization or certifying body is attesting to the students' knowledge in a particular domain.

Curricular Usage of Cloud

Examples of incorporating cloud concepts into higher education curriculum exist at least as far back as 2011, where Wang et al. (2011) explored it from a system administration perspective using an open-source stack to develop a private cloud. Chen et al. (2012) looked at incorporating public cloud services from Azure and AWS into separate data analysis and web development courses as short topics within the overall courses.

Lawler (2011) draws a strong connection between the IS 2009 Curriculum Model and cloud computing as it is transforming organizations and how they deliver IT services. Furthermore, he argues that cloud computing should be introduced earlier in the curriculum. One such implementation was done by Woods (2018) where AWS was utilized in an introductory IT course for students to deploy Python code and experiment with Linux. Students in this particular study found value in having hands-on experience with AWS and understanding how the infrastructure worked behind-the-scenes (Woods, 2018).

More recently, Palmer and Kim from Ovum Consulting (2019) analyzed the AWS usage of Arizona State University, Notre Dame and University of Queensland, both in their curriculum and as the infrastructure platform for the universities. Most of the research centered around how quickly universities can innovate in their IT curricula by leverage cloud platforms. Ovum concluded that university IT organizations "will be hard-pressed to support the institution through change" without the adoption of cloud platforms, due to the pace of technical innovation and the sheer variety of tools being leveraged in the industry. Furthermore, they conclude cloud platforms can improve cost effectiveness of IT related degree programs, enable more innovation in curricula, and better prepare students for careers of the future (2019).

While some universities may have the resources and infrastructure to build out their own private cloud with IT resources for student work in IS/IT courses, not all institutions have the capital to stand up and maintain their own data centers. Whether students need server space for web applications, database design and querying, or general computation, the costs incurred in both time and money can be difficult for smaller institutions to manage. Cloud technologies can enable resource-strapped programs to leverage in-demand technologies (Mew, 2016).

Given the body of literature from both peer-reviewed and industry sources, there is a baseline case that the growing use of cloud technologies in industry is a necessary element in IS/IT curricula for students to remain relevant in their skill development for marketability as IS/IT professionals. Previous research also supports the conclusion that integrating cloud into higher education curriculum is key to maintaining a relevant and forward-thinking program while also shifting the burden of course technologies away from on-premises data centers. Given the prominence of current and future cloud usage, this research strives to address ways in which cloud computing can be effectively incorporated into computing curricula.

3. METHODOLOGY

Cloud Platform Selection

While there are several vendors in the cloud computing space, AWS was chosen for its free cost to students, its robust educational platform, its accessible entry-level certification, and its market share. According to Gartner (2020), AWS is considered to be the highest rated in terms of ability to execute and completeness of vision using their patented Magic Quadrant analysis. In addition, others have documented success with using AWS in the classroom based on previous studies (Wang et al., 2011; Chen et al., 2012; Woods, 2018). In a multi-year study completed by IT professionals related to the IT/IS knowledge and skills in demand by employers, the trends were leaning toward demand in cloud skills as well as the rising stature of AWS. The results indicate a shift away from Google to AWS and Azure compared to prior results, although respondents were mixed between the importance of cloud technologies growing or remaining the same (Janicki & Cummings, 2020).

Course Design

This Systems Administration course was designed to incorporate both industry and academic perspectives provided by the combined efforts of the information systems professor along with an industry practitioner. The learning objectives for the course, while broad, can be distilled down to two main pedagogical goals: provide the students with a fundamental and provider-agnostic understanding of cloud concepts and technology, and prepare the students for careers in technology through the completion of an industry recognized certification. Overarching concepts are going to be slower to change than a specific vendor or software platform, which will serve the students better over time.

In order to accomplish the first goal of the course, a provider-agnostic text by Thomas Erl, Ricardo Puttini, and Zaigham Mahmood: "Cloud Computing: Concepts, Technology & Architecture" (2013) was utilized. This text focused on common technology that is leveraged across public, private and hybrid cloud platforms, and the underlying systems that power those platforms. Having been written in 2013, there were aspects to the textbook that have since become less relevant than when originally written. Specifically, there was a great deal of focus on how to build and manage a cloud platform versus how to leverage an existing cloud provider like Amazon Web Services in efficient and scalable ways. To address some of those shortcomings, external whitepapers and the industry perspective were provided to help contextualize the consumer interaction with a cloud platform. In surveying leading textbook publishers, the majority of titles were either vendor-specific or focused on a sub-category within cloud such as security or governance with few options left for a book that focused on cloud fundamentals.

The course was taught over sixteen weeks, with the first twelve being focused primarily on content delivery, and the last four a mixture of final project and preparation for the certification exam. To ensure the class maintained a provider-agnostic focus while still adequately preparing the students for the exam, the course was designed to follow the text and then the AWS specific skills and exam topics were subsequently mapped to each chapter (see Figure 2 in Appendix A). The core content centered around cloud concepts and models, cloud security, infrastructure, monitoring, management, delivery models, cost metrics, and pricing models. These overarching concepts were presented and then interleaved with hands-on opportunities in AWS such as deploying Windows and Linux instances, configuring identity management, creating and managing a cloud database, and building a budget for a cloud deployment. A course outline can be found below in Table 1.

Systems Administration Course Outline	
Week 1	Intro to System Administration AWS Introduction
Week 2	Understanding Cloud Computing Virtualization and Linux Review
Week 3	Fundamental Cloud Concepts and Models
Week 4	Containers/Serverless Building Container Services using AWS
Week 5	Fundamentals of Cloud Security
Week 6	Cloud Infrastructure Mechanisms
Week 7	Monitoring and Alerting Business Continuity
Week 8	Cloud Management
Week 9	Configuration Management Cloud Security Mechanisms
Week 10	Identity Management Cloud Delivery Model Considerations
Week 11	Database Management in the Cloud
Week 12	Cost Metrics and Pricing Models
Week 13	Review Key Concepts Final Project Work
Week 14	Prepare for AWS Certification Exam
Week 15	AWS Practice Exam and Final Project Work
Week 16	AWS Cloud Practitioner Exam Final Project

Table 1: Systems Administration Course Outline

Lab Exercises in AWS

A key lesson learned from the course was how to successfully manage the chosen cloud platform in a way that allows the students broad access to explore the provided services, but still maintained safeguards against surprise costs associated with the use of those services. AWS, along with many of the other cloud vendors, allows customers to set up accounts for free and access a range of services without incurring costs under a "free tier". This tier includes the use of "micro" sized VMs (1 virtual CPU core and 1 GB of RAM), as well as small volumes of other services such as object storage and managed databases. To fully leverage these offerings, students in the class were given instructions on setting up their own AWS account using their own contact and payment information. That account gave students their own cloud environment, with access to all the services that an enterprise IT organization would have.

Course material and quizzes were supplemented with hands-on work in the form of lab exercises to help bring the concepts to life. These labs fell into two general categories: prescriptive labs where students were given step-by-step directions and more abstract case studies where the students were given real world challenges to solve with limited direction. Throughout the course, students created Linux and Windows virtual machines (VM), learned how to use S3 storage in conjunction with a static website, and built and performed queries on a MySQL database using Amazon RDS. In addition, students analyzed a business case to identify architecture requirements and provide cost estimates as well develop an organizational identity and access management structure.

The midterm and final projects combined aspects of both types of labs. For the midterm, students were given the challenge to combine concepts from previous labs, such as VM creation and networking in order to build a self-hosted WordPress website on EC2. For the final project, students were given a choice of four options, each of which focused on slightly different concepts so students could tailor their choice to their personal interests. Students could choose between automating the deployment of Minecraft servers, creating a continuous delivery pipeline using Amazon Elastic Beanstalk and Amazon's Code(*) suite of services, deploying a LAMP (Linux, Apache, MySQL, PHP) stack web application, or automating application programming interface (API) calls to retrieve weather data. Most students elected to build a LAMP stack application, likely due to the resemblance to the skills developed in the midterm.

Each lab was assessed using the rubric as seen in Appendix A, Figure 3. Students were required to document their work using technical language and screen shots such that another person could follow their work to reproduce the same results. Their work was also assessed for their ability to produce a working environment, that steps were executed properly, and that testing was done to ensure that services were working properly. In addition, students were asked to reflect on the lab and draw connections to course material from this class and others, how organizations could benefit from the AWS cloud service, and to connect the lab to their desired careers.

Certification Exam

The AWS Certified Cloud Practitioner exam was intentionally built into this course as a way for students to build their resumé while still in school to increase their marketability as IS/IT professionals. With AWS controlling approximately 32% of the global cloud computing market as of 2020 (Richter, 2021), the AWS Cloud Practitioner has become the de facto credential for IT professionals working in a cloud environment. The AWS Certified Cloud Practitioner examination focuses on four main topics: cloud concepts, security and compliance, [core] technology, and billing and pricing (Amazon Web Services [AWS], n.d.). Course topics can be seen mapped to AWS Cloud Practitioner domain areas in Appendix A, Figure 2.

The cost of the exam as of October 2020 was $100 USD (Amazon Web Services, n.d.). For this pilot, a corporate sponsor and strong institutional supporter funded the cost of exams for every student in the course regardless of whether they passed the exam. While the corporate funding lowered the barriers to entry for students, there is anecdotal evidence from course feedback surveys that the price is within most students' willingness to pay for the opportunity to earn an industry credential. Passing the AWS Cloud Practitioner Exam was not weighted in such a way that it would prevent a student from passing the course (15% of total grade). While the instructors' combined experiences and Gomillion's (2017) research both supported the importance of obtaining the certification, the goal was still to allow students to balance their time appropriately between focusing on foundational concepts, hands-on lab exercises, and preparing for the exam.

4. RESULTS

Because of the small class size, drawing statistical conclusions was not possible. However, comments from the pre-course survey, student reflections, lab assessment data, and exam scores provided insight into the outcomes of the course. This section will highlight these specific areas.

Pre-course Survey

At the beginning of the course, students were given a survey to gauge their level of comfort with the curriculum and their level of interest in different aspects of the course. Students generally felt excited about the course, though few of them claimed any experience with cloud technology outside of SaaS solutions like Google Drive or Office 365. Another common sentiment expressed by the students was anticipation for the certification exam. All the students responded that they found the incorporation of the AWS Cloud Practitioner certification very valuable, and while the cost of the exam was being covered by a corporate sponsor, half responded that they would take the exam even if they had to cover the costs themselves.

Lab Assessment

Throughout the ten labs in the course, several trends were observed. Generally, students excelled in the guided work. More often than not, all the students successfully completed the steps outlined in the lab and could troubleshoot their way through any errors they encountered with minimal guidance from the instructors. Where students tended to fall short was in the technical documentation, and reflection components of the labs. For many of the students, the documentation served only to prove that they completed the labs but did not contain enough detail to have guided someone else through the same process. Similarly, in the reflections, several students simply summarized their work and the comprehension of the base learning objective without synthesizing into how that skill could apply to real world scenarios or connecting it with topics covered in other classes. One exception to this trend was in the final reflection that accompanied the final project. This reflection counted for a more substantial part of the overall project grade, and it asked the students to reflect on their learning throughout the entire class instead of the specific project.

When reflecting over the class as a whole, students were able to articulate many of the outcomes the class had been designed to achieve. One student reflected, "It [the class] taught me how to navigate understanding and conversation about different aspects of IT." Naturally, technical issues will occur, and students recognized that "when working with technical platforms to complete a certain goal or problem, things will often not go as planned or not work the first time." While not cloud specific, the labs did help students understand the value of learning general troubleshooting and problem-solving skills. Most importantly, students came away understanding the value cloud computing has in the future of IT architecture. One student remarked that "…how a company, big or small, can utilize the cloud, and how relevant the cloud is." Likewise, in general, another student recognized that "Truly cloud computing resonates with me because I know that I use the cloud every day."

Certification Exam Results

Of the five students who took the certification exam, three passed and earned the AWS Certified Cloud Practitioner credential. An exam is considered passing with a score of 700 out of 1,000 points. Exam scores in the class ranged from 541 to 905 with a median of 760 and an average score of 718.2. After comparing course grade data with AWS exam results, those who passed the exam also performed best in the class in terms of their final grade. These students typically prepared their assignments at a level that demonstrated understanding of the material, were able to connect the content to other topics they had learned and took outside opportunities like webinars and free training to learn more about AWS. As a practitioner certification, the CLF-C01 is not designed to demonstrate an in-depth technical knowledge of the AWS suite of tools, but rather a general understanding of cloud principles regardless of job role (Amazon Web Services, n.d.). As such, having a student feel prepared to handle conversations involving cloud computing is an ideal outcome for the class.

5. DISCUSSION AND CONCLUSIONS

This paper outlines the design and implementation of the first iteration of incorporating cloud technology into the IS curriculum of a private 4-year university. The lessons learned in this class will serve as a guide for other classes within the major, and to other educators looking to enrich their courses.

Throughout the course, a major struggle was balancing the desire to teach topics in a flexible, provider agnostic way, and the need to prepare students for the topics and specific services covered in the CLF-C01 exam. For the reasons mentioned previously in the paper, the benefits of teaching AWS seemed to outweigh the risks, but in the final reflection some students did express a desire for a wider breadth of exposure to other providers. Specifically, one student stated: "One thing that I wish would have been incorporated in this class would be discussing the advantages and disadvantages of GCP and Azure compared to AWS". While finding instructors or texts that can effectively speak to all 3 of the major cloud providers equally is incredibly challenging, at least providing a solid foundation of the different platforms could better set students up for real-world hybrid-cloud scenarios.

The course served students who had varying career aspirations. Some students taking the course were pursuing developer positions while others were more interested in becoming business analysts. For example, one student commented in a reflection question that "while not entirely sure that my career path will directly involve those AWS services, I think knowing more about the concepts behind those services and how they can be utilized will make me more knowledgeable and well-rounded when working as a developer."

It is difficult to expect every institution to have access to industry professionals who can bring in-depth knowledge of cloud computing to the classroom. For faculty looking to implement cloud computing into their curriculum without previous cloud experience, it is highly recommended they find a way to familiarize themselves with the various platforms and services available. Each major cloud provider, Amazon, Google and Microsoft, has their own foundational certifications and corresponding free online training, similar to the CLF-C01 AWS Cloud Practitioner Exam leveraged in this course. Studying for and achieving one of these certifications is an effective way to properly prepare for and have a level of understanding of cloud computing to successfully teach a class like this.

After further use of AWS in subsequent classes, AWS's educational offering, *AWS Educate*, proved to be a platform with useful additional classroom management features. In *AWS Educate,* students receive $50 in AWS credits to use across their entire portfolio of products and faculty receive $200 in credits to use for shared environments and testing. Faculty can also manage classroom enrollments and get some insight into students' environments. As of December 2021, AWS is transitioning their *AWS Educate* platform to their new *AWS Academy* platform. At the time of this research, not enough information is available to share the differences between *AWS Educate* and *AWS Academy.*

Another important reflection is the limited visibility and higher risk posed by students using individual AWS accounts. While there was little overhead in costs of having each student have their own AWS accounts, it also meant the instructors did not have access to view the services they were spinning up. Due to this limitation, grading relied heavily on the student's provided documentation of their steps. It also meant troubleshooting issues for the students required one-on-one meetings so they could share their screens. An alternative strategy that has been leveraged in subsequent courses is to manage a centralized AWS account that all students log in to. This method provides increased visibility at the expense of extra management overhead by the instructor.

This course redesign was an important step in identifying ways to better incorporate cloud computing into the IS curriculum. Since the course was offered, some lab exercises have been repurposed for use in pre-requisite courses like Foundations of Information Systems and IT Infrastructure. Specifically, the sections involving server virtualization and cloud storage have worked well in the lower-level IT Infrastructure course. Putting those elements into supporting courses provides the opportunity to move to more sophisticated lab exercises focusing on topics like containerization and infrastructure as code in the next iteration of this systems administration course. The future goal would be to offer the course again connected to the AWS Cloud Practitioner Certification to not only benefit students, but to also gather more data on student outcomes in-class and as alumni.

Naturally, additional research is needed to better assess the most effective methods for incorporating cloud computing into the curriculum, but these lessons can provide guidance to other educators wishing to pursue teaching cloud concepts. It is the authors' hope that future courses will garner higher enrollment and allow for continued research and a larger sample of student data from which to validate these initial results.

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Appendix A

Systems Administration Course Topics Mapped to AWS Cloud Practioner Domain Areas			
Course Topics	**AWS Cloud Practioner Domain Areas**		
	Domain 1: Cloud Concepts		26%
History of Enterprise Data Operations		1.1 Define AWS cloud and it's value proposition	
Review Infrastructure and Virtualization		1.2 Identify aspects of AWS Cloud economics	
Understanding Cloud Computing		1.3 List different cloud architecture design principles	
	Domain 2: Security and Compliance		25%
Cloud Security Fundamentals		2.1 Define the AWS shared responsibility model	
Service Quality Metrics and SLAs		2.2 Define AWS Cloud security and compliance concepts	
Cloud Security and Access Management		2.3 Identify AWS access management capabilities	
Monitoring and Alerting		2.4 Identify resources for security support	
	Domain 3: Technology		33%
Cloud Compute: Serverless and Containers		3.1 Define methods of deploying and operating in the AWS Cloud	
AWS Global Infrastructure		3.3 Define the AWS global infrastructure	
Cloud Storage and Databases		3.3 identify the core AWS services	
Cloud Infrastructure Management & Automation		3.4 Identify resources for technology support	
	Domain 4: Billing and Pricing		13%
Cloud Delivery Model Considerations		4.1 Compare and contrast the various pricing models for AWS	
Cost Metrics and Pricing Models		4.2 Recognize the various account structures in relation to AWS billing and pricing	
		4.3 Identify resources available for billing support	

Figure 2. Course Topics Mapped to AWS Cloud Practitioner Domain Areas

	Mastered 4	Proficient 3	Developing 2	Beginning 1
Start Service Successfully (10%)	All Services in the lab started correctly without errors	Most services in the lab started correctly without errors or contained minor errors	Some services in the lab started correctly without errors or contained errors that prevented them from starting	Few services in the lab started or contained major errors
Execution (25%)	Lab steps have been executed fully and according to directions paying attention to detail	Lab steps have been executed mostly and according to most of the lab instructions	Some lab steps have been executed, some steps not in the correct order, or have been left out	Little attempt was made to complete the lab steps according to the instructions
Testing (20%)	Project has been fully tested, services are verified operational, with exceptions noted in detail	Project has been mostly tested, services are verified operational, exceptions may not be detailed.	Project has been partially tested, services may not have been verified operational, exceptions may not be noted	No attempt to test or note any exceptions
Documentation (25%)	Documentation is fully complete, accurate, professional, and appropriate to target audience(s)	Documentation is mostly complete or mostly professional, highly accurate with only minimal divergence in audience appropriateness	Documentation is well attempted though missing portions, has more than minor inaccuracies, or is not appropriately framed for the target audience	Documentation is insufficient or missing, has major errors, or is not created to the appropriate level
Reflection and Application (20%)	Student reflected on the lab in a way that demonstrates a connection to the course material, use case, or real life application citing multiple examples	Student reflected on the lab in a way that demonstrates a connection to the course material, use case, or real life application citing at least one example	Student partially reflected on the lab that connected to the course material, but lacked depth or detail	Student made an attempt to reflect on the lab, but was insufficient

Figure 3. AWS Lab Assessment Rubric