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Conquer the Cloud: Effectively Using the Amazon Web Services Academy Learner Lab for Information Systems Education

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Abstract

Information systems students yearn for hands-on, active learning experiences that teach relevant skills. Delivering these experiences requires repeatable, secure, and scalable computing infrastructure. Unfortunately, many institutions struggle with the capital and operational costs of hosting in-house computing environments. Some educational platforms give access to inflexible environments that limit instructors' options for curriculum design. Through the Amazon Web Services Academy, educators can use the Learner Lab environment to provide students with a managed environment for developing code and testing infrastructure in the cloud with modest limitations. We present a set of best practices based on our years of experience teaching Information Systems students in the Learner Lab environment. The best practices address pedagogy, student onboarding, architectural guidance, and curriculum development.

Keywords: cloud computing, computing hardware, AWS Academy Learner Lab

1. INTRODUCTION

Cloud computing has revolutionized how organizations manage, maintain, and deploy systems. Organizations demand scalable, secure, and cost-effective solutions; cloud computing can increasingly address these challenges. Educators can leverage these same benefits by embracing the cloud. This paper explores the significance of leveraging cloud computing using the Amazon Web Services (AWS) Academy Learner Lab environment and its impact on Information Systems education.

Why Universities Need the Cloud

Virtual machines provide repeatable, standardized, and segmented computing environments that educators can leverage to teach practical knowledge and skills. Desktop hypervisors (such as Oracle VirtualBox and VMWare Workstation Player) and server hypervisors (such as VMWare ESXi and Proxmox) provide a layer of abstraction so that the same virtual machine should run the same regardless of host computer differences. A critical question universities must ask is, "Where should the virtual machines be deployed?"

Disk, CPU, and RAM limitations on student computers restrict the size and number of virtual machines. Differences in CPU type (e.g., x64, ARM, Apple M) add devices with organizational restrictions increase the configuration challenges. Some student devices, such as phones, tablets, and Chromebooks, cannot support the virtualization of other systems (Brereton, 2022). Hosting lab virtual machines, whether in-house, by third parties, or in the cloud, removes the concerns of students needing more compute resources from the virtualization equation.

In-house private clouds require significant capital expenditures and add administrative burden to maintain on-premises computing infrastructure. Additionally, universities must allocate funds for power, maintenance, and upgrades (Murphy & McClelland, 2009). Cloud computing solves many of these university challenges (Mew, 2016). Instead of provisioning infrastructure for peak capacity, universities can elastically provision and deprovision resources as needed. When empowered with the cloud, educators can manage their lab environments without hardware, software, or operational support from their IT departments. The cloud, specifically the Amazon Web Services Academy Learner Lab, makes this possible.

AWS Academy

AWS Academy provides higher education institutions with a hands-on cloud computing curriculum at no cost to institutions or students (Nwokeji et al., 2021). It uses Canvas to organize lesson materials and provide a portal to the real AWS cloud. Students leverage the AWS Academy to prepare for industry-recognized certifications and in-demand jobs. Hundreds of institutions have adopted the AWS Academy for data analytics, Information Systems, cybersecurity, and general cloud awareness.

The AWS Academy is composed of many distinct courses. For example, the Cloud Foundations course teaches principles of cloud computing with readings, videos, and hands-on labs. Except for the Learner Lab environment, all AWS Academy courses contain curriculum, lab exercises, and quizzes developed and supported by Amazon. The Learner Lab course is distinct in that it provides more flexibility to the instructor to craft assignments and will remain the focus of the rest of the paper.

Learner Lab Course

The Learner Lab course provides students with restricted AWS services for ad hoc creation and exploration of AWS services. When an instructor enrolls a student in a Learner Lab course, AWS provides an AWS environment for their personal use. Each student receives a course lab credit amount to spend in the AWS cloud without giving credit card information, and AWS never charges students for resource use. The AWS environment leverages the same AWS resources provided to AWS customers but with some resource usage limitations. Unlike other AWS Academy courses, resources within the Learner Lab persist, allowing students to revisit their work over time. Some resources (such as virtual machines) are automatically powered down after periods of inactivity to help manage credits efficiently. Credits are discussed further in this paper's "Cost Management" section.

The Learner lab lets students experiment with real-world information technology scenarios. In the Learner Lab, students can destroy, create, and extend systems beyond classroom instruction. By working hands-on in cloud environments, they bridge the gap between theory and practice, preparing themselves for the complexities of the professional world.

As educators, we experienced several speedbumps when first teaching within the Learner Lab environment. The purpose of this paper is to share best practices to help educators:

1. Get started with the AWS Academy Learner Lab
2. Prevent accidental abuse of the Learner Lab environment
3. Develop a curriculum to leverage the opportunities in the cloud

By following the principles in this document, educators will reduce time spent developing curriculum, making it easier for students to complete exercises, and ensure compliance with AWS Academy policies.

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2. USING THE AWS LEARNER LAB

This section describes how educators can start with AWS Academy, create Learner Lab courses, and provide practical recommendations for using the Learner Lab effectively.

AWS Academy Onboarding

Amazon requires that universities become "member institutions" before using the AWS Academy. One person from the member institution becomes the lead responsible for managing the institutional relationship with AWS Academy. This manager must attend online AWS Academy training and accept AWS terms of service. Once AWS approves the institution, the institution's lead nominates instructors. Instructors must complete a short onboarding course before teaching any AWS Academy course. The onboarding process to become a member institution and approve instructors is simple, though it can take several weeks. Figure 1 summarizes this process.

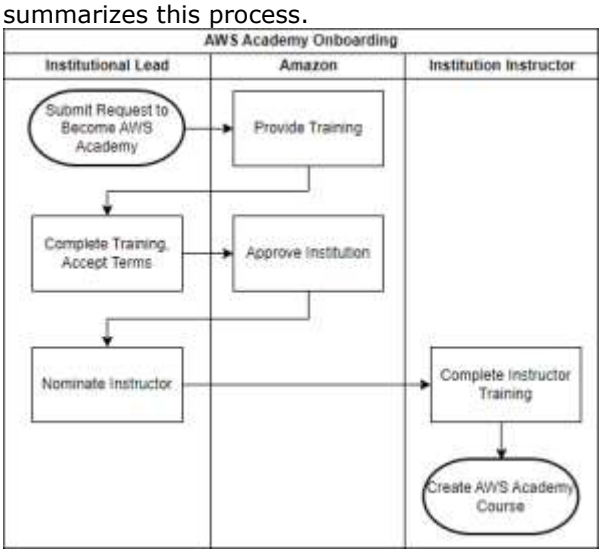

Figure 1 AWS Academy Onboarding Process

AWS Academy LMS

AWS Academy hosts all its courses using the Canvas learning management system (LMS). Instructors can create any course in the AWS Academy curriculum. Instructors invite students to courses using email addresses. While most AWS Academy courses include instructions and labs curated by AWS, the Learner Lab provides educators with a sandbox in which educators can provide custom instruction and labs. The Learner Lab is a good fit for educators who need resources to run custom labs and exercises.

Classroom Management

As a best practice, educators should create a Learner Lab section in the LMS for each course. Segmenting courses will limit the fallout if one section is decommissioned prematurely due to egregious violations. While the Learner Lab environments persist, educators should know that the entire lab course could be unpublished due to technical problems or severe policy violations. The workflow for creating a course and how the student enrollment process occurs is in Figure 2.

Before inviting students to an AWS Learner Lab environment, instructors should summarize key acceptable use policies before inviting students to a Learner Lab course and ideally require them to pass a quiz on those policies. A quiz (such as the sample in Appendix B) serves as a deterrent control and establishes an audit trail to reinforce the acceptable use policy.

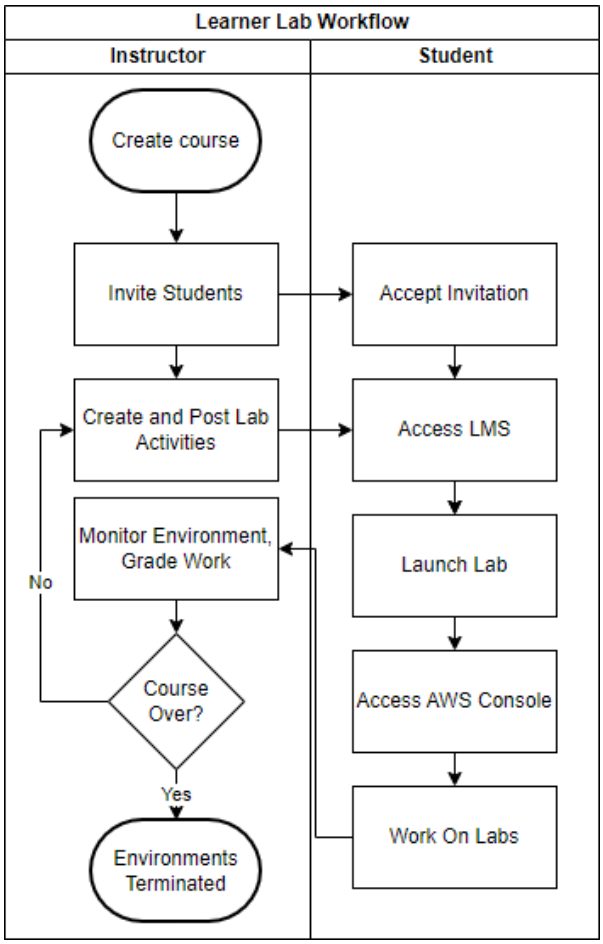

Figure 2 Classroom Management

The AWS Academy LMS gives students an acceptable use policy on the first login. Since the policy is long and extensive, most students scroll to the bottom of the page and accept it without reading it. However, specific uses of the Learner

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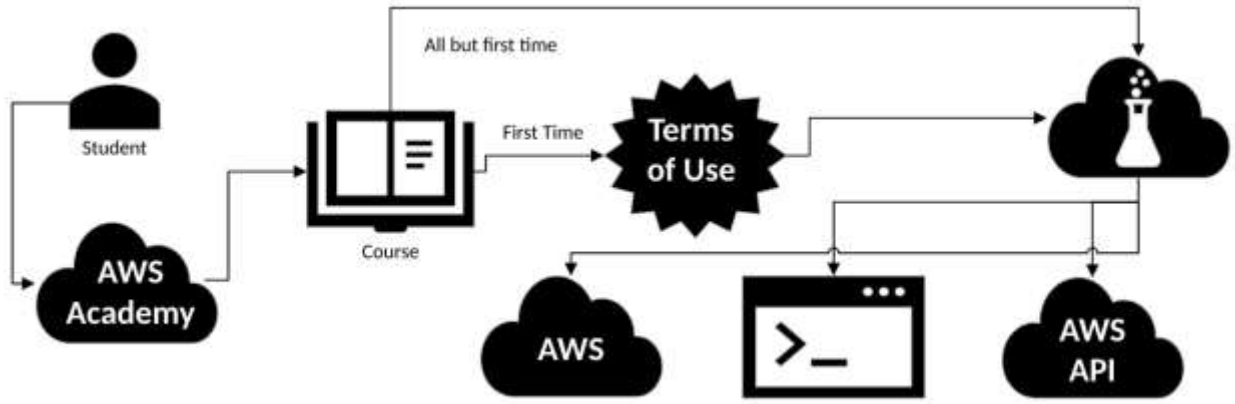

Figure 3 Student Workflow

Labs (such as mining cryptocurrency) automatically trigger AWS Academy account deactivation.

If students are in several AWS Academy courses, it is a best practice to add students to a single course initially. This approach streamlines the account creation process for new students. Instructors should educate students about the potential confusion surrounding login credentials. Since single sign-on or federation is not available, many students mistakenly use their university login credentials instead of their AWS Academy credentials. Students must log in with the invited email, not an alias. Instructors should encourage students to help each other and validate that they have completed the enrollment process and can access the course's Learner Lab environment.

Students with personal AWS accounts may experience a conflict between individual and AWS Learner Lab environments. The fix is simple: Students log out of the AWS Management Console and relaunch the Learner Lab environment from the Learner Lab course. Students with personal AWS accounts can check which environment they are using by observing the user identity in the top-right corner of the AWS control panel to avoid unwanted charges. Accounts through Learner Lab will start with "voclabs/user" and be followed by numbers.

Though the cloud removes nearly all client configuration challenges, ad blockers, privacy tools, and browser cookie settings can interfere with the Learner Lab, requiring some browser troubleshooting after onboarding.

Figure 3 shows a student's process to access AWS services through the Learner Lab course. Following this process, the student will have access to the AWS Management Console in a browser tab in just a few minutes. Students can investigate, configure, provision, and manage cloud resources like working professionals.

Vocareum

Vocareum is the bridge between AWS Academy Canvas and the AWS cloud. The Vocareum integration happens automatically when instructors create Learner Lab courses. When a student enrolls in a Learner Lab course, Vocareum provisions the student's AWS cloud environment with security keys and policies that access some AWS resources. The Vocareum interface is linked to from a module in the Canvas Learner Lab course. The Vocareum interface allows students to launch their environment, download SSH keys and credentials (through the AWS Details link), access the AWS web console (through the AWS link with a green circle), shut down resources, and more.

The Vocareum interface allows instructors to monitor, change, or evaluate student workspaces, allowing instructors to help students troubleshoot and fix issues. Instructors can also request help with Vocareum-specific issues.

Persistence

The AWS Academy Learner Lab offers a long-running lab environment suitable for student projects for up to 6 months. However, some resources have specific time limits. For example, Vocareum will shut down, but not delete, Elastic Compute Cloud (EC2) instances four hours after starting up the Learner Lab. Students can restart the four-hour limit by restarting the session manually if more time is needed. However, extending the lab sometimes results in power cycling the running EC2 instances and may result in a change in the public IP address. EC2 instances will not automatically terminate (i.e.,

deleted) unless abuse is detected. When students access the lab, all resources will start automatically. This persistence allows students to keep working where they left off but can create challenges when systems have dependencies that require instances to start in a particular order. Students should set any order-dependent services, such as database clustering, to manually rebuild the cluster in the necessary order. An overview of author-endorsed AWS components is in Appendix A.

Learner Lab Service Restrictions
The AWS Academy Learner Lab provides access to a restricted set of AWS services. The AWS Academy Learner Lab Foundation Services Guide documents the specific services and their limitations. For example, some expensive managed services are disabled, EC2 instances cannot be created from custom AMIs, and students cannot provision virtual machines with many GPUs.

3. PEDAGOGICAL SUGGESTIONS

The same pedagogical best practices educators use can be leveraged in cloud environments. The Learner Lab supports active learning through hands-on projects and group work. Educators provide opportunities for differentiated instruction by challenging students to extend assignments in novel ways. Educators can use the Learner Lab for formative assessment by inspecting student workspaces to assess comprehension. The Learner Lab supports inclusivity by removing barriers, like a student with a resource-constrained laptop. This section focuses on how educators can incorporate pedagogical best practices with the Learner Lab.

Course Sequencing
Instructors can reap numerous advantages by introducing students to the Learner Lab early in their academic program. Students can acquire the fundamentals of cloud computing early in their degree programs (Woods, 2018; Poteschi & Debo, 2022). They can apply these skills to more complex subjects and real-world situations as they move through their courses. They continue using the Learner Lab to work on projects unique to their courses, practice using AWS services, and review material. Using the Learner Lab in multiple courses reinforces learning, smooths integration, and fosters continuity. By understanding cloud technology through several classes using the Learner Lab, students can see the interactions between various services, pick up best practices, and hone their problem-solving skills. See the appendix D for a sample course sequencing.

The Learner Lab allows students to leverage knowledge and skills acquired from prerequisite courses. For instance, if Python is included in previous classes, students can use the Learner Lab for serverless computing with AWS Lambda and data analysis with Jupyter Notebooks (Mitri, 2023). Using Python in AWS reinforces students' Python skills. It provides a practical application of these skills within the AWS environment, helping strengthen the Python learned in the prior course and showing its uses in industry.

Moreover, exploring other AWS services that align with the content of different classes is beneficial. For example, if a database course is part of the curriculum, introducing AWS RDS (Relational Database Service) or DynamoDB could provide students with hands-on experience in managing and interacting with databases in the cloud. Similarly, incorporating AWS Amplify or Elastic Beanstalk could be beneficial if a course covers web development.

By integrating AWS services that complement the curriculum, students can see the direct application of their classroom learning in a real-world, industry-standard, industry-leading environment. This approach equips them with valuable skills that are highly sought after in the tech industry and still underrepresented in academic institutions (Cite Chen et al., 2012; Mew & Money, 2018; Pike & Brown, 2019; Milosevic et al., 2022; Flood & Hall, 2022)

Learner Lab Onboarding Support
The cloud can be complex and intimidating. The Learner Lab contains short videos that address primary use cases, such as accessing EC2 instances via SSH. However, educators should consider adding additional content, including videos that support the onboarding process. For example, educators might cover such issues as encountering pages that do not load properly or repeatedly accepting terms of service, which are typical in the first-time setup process.

Other Supporting Content
Cloud Foundations, a separate course in AWS Academy, can be used to introduce the complexities of the AWS cloud environment gradually. Cloud Foundations includes introductory videos and labs that introduce foundational cloud computing concepts. Instructors should provide additional content, such as shorter videos focusing only on the most challenging aspects of the first few tasks. Limiting explicit guidance promotes critical thinking and independence.

Instructional materials must be refreshed regularly as AWS constantly expands its service, necessitating user interface changes. Furthermore, the Learner Lab is continuously updated to address the changing AWS environment and the changing needs of academia. Consider leveraging videos from others to avoid having to update them yourself constantly.

Building Scaffolded Learning Experiences

The Learner Lab can be considered a blank slate, where instructors can help students progress in understanding. Bloom's taxonomy is one helpful way to think about a student's learning journey. Students cannot create a solution to a problem until they can remember facts, understand the concepts, apply the information they have learned to new situations, analyze the connections between concepts, and evaluate options for solving a problem (Krathwohl, 2002). Using the cloud does not change anything about how we teach our students, but it gives students access to the tools that allow them to create a solution once they are knowledgeable enough within the appropriate domain.

When creating a course, it is suggested that educators use a scaffolded approach. For instance, instructors could create a sequence of projects and tasks that require students to move up the taxonomy, starting with labs that provide step-by-step instructions (which we call guided labs to keep with the terminology in other AWS Academy courses), labs that leave some details up to students to figure out (which we call challenge tasks to keep with the terminology in other AWS Academy courses), and finally new an original projects that students can create (which we call independent projects).

Guided Labs (remember and understand): Students follow step-by-step instructions to complete specific tasks. This approach is beneficial for beginners who are just getting started with AWS services. It allows them to gain a basic understanding and comprehension of the tools and concepts.

Challenge Tasks (apply, analyze, and evaluate): Educators can present students with tasks or problems to solve using the AWS services using high-level prompts. This approach encourages students to apply their knowledge, analyze solutions, and synthesize information to achieve the desired outcome.

Independent Projects (create): Educators can assign students to design and implement their projects within the AWS environment. This not only tests students' understanding and application of AWS services but also their ability to evaluate and make judgments about their work and the work of others. At this level, minimal instructions challenge students to solve complex problems, make decisions, and create original solutions. Students find real-world scenarios to do self-initiated project work. This experiential learning helps students see how the learning they have achieved can be applied after graduation.

Consider the Real-World Impact

Remember that students need context to understand the technology and why it matters. It is valuable to encourage students to explore the real-world applications of AWS skills beyond the classroom. Encouraging students to research companies or job opportunities in regions where they aspire to work can provide valuable insights into the relevance and high demand for cloud computing expertise in various industries and locations (Chen et a. 2012). This broader perspective reinforces the practical significance of utilizing AWS tools for learning, underscoring their value in post-education career pursuits.

4. LEARNER LAB TECHNICAL BEST PRACTICES

The authors of this paper each ran into issues when teaching with the Learner Lab for the first time. This section contains some best practices we have learned to help educators effectively leverage the technical components of the Learner Lab. Following this guidance, educators new to the Learner Lab can avoid pitfalls and embrace best practices for working with the Learner Lab's features and constraints.

Managing Key Pairs

All AWS customers (including Learner Lab students) are responsible for securing access to resources in the AWS cloud. Students maintain access control lists, passwords, and keys. AWS relies on key pairs–a public key and an associated private key–to secure access to many resources. Students must protect private keys like any other sensitive data. Students can either 1) use the key pairs provided by Vocareum or 2) create their key pairs. Instructors should require students to manage their keys if key management is a critical learning objective. Otherwise, the Vocareum keys should be used to minimize troubleshooting and access problems. We suggest the following two options.

Option 1: Use Vocareum's Key Pair

Vocareum provisions each student's Learner Lab

environment key pair. Students download their public and private keys in the Learner Lab course. If students lose their key pairs, they can redownload their keys. Relying on these existing keys makes it easier for students to maintain access to their resources, but students miss the learning opportunity to learn about key management practices.

Option 2: Manage Custom Key Pairs
Students can create key pairs using tools like ssh-keygen or the AWS Management Console. If students create their keys using ssh-keygen, they must upload the public key to their AWS Management Console to enable its use. If students lose their custom private keys, they lose access to their resources until they associate new keys with existing resources.

Cost Management
AWS provides students with limited credits without guarantee that those credits can be increased. Generally, students spend well under their allotted credits. However, a few critical mistakes can increase credit spending substantially. Cost management primarily comprises three practices: service selection, service sizing, and session management.

Manage Cost with Service Selection
Generally, avoid paid managed services. Some AWS managed services would deplete students' budgets in weeks, even with little to no usage. Instructors should use pricing calculators when developing exercises to anticipate costs. It is sometimes necessary to build scaled-down services that mimic managed services. For example, students can grant EC2 instances Internet access in private subnets using manually built NAT instances or implement the AWS-managed NAT Gateway. A NAT instance might cost a few dollars over a semester, whereas the AWS-managed NAT Gateway could consume the student's allotted credits alone.

Many services are free or scale directly with usage. For example, VPCs, Internet Gateways, and S3 buckets incur no costs alone. Charges are only incurred for data stored in S3 buckets or EC2 instances created in VPCs.

Manage Costs with Service Sizing
Size EC2 instances as small as possible to achieve an acceptable level of service. A sufficient Linux instance (t3.micro, with two virtual CPUs and a gig of memory) costs a penny per hour. Looking at a large Linux instance (t3.2xlarge, with eight virtual CPUs and 32 gigs of memory) costs 33 cents an hour. These costs add up quickly, especially when multiple instances are created and run over a semester.

In one author's class, a student exhausted the free credit provided on the account in weeks by oversizing EC2 instances. Also, the student provisioned a new instance each time they got stuck without terminating the previous ones. The student provisioned dozens of large servers instead of a small server. In another case, a student showed the faculty member a pricing estimate for the CloudWatch logs that were being used to fire off other services across the AWS infrastructure that was more than USD 100.00 per month. By reducing the number of events that were being logged, the same effect was possible for less than USD 5.00 per month. Instructors can and should monitor lab spending using the Learner Lab's instructor interface, especially early in the term.

Manage Cost with Session Management
Students should actively end their lab sessions when they finish their tasks rather than wait for Vocareum to put those services to sleep. Keeping labs running can result in unexpected costs, particularly for resources that incur charges based on usage or, in some rare instances, the lack of usage once provisioned (such as elastic IP addresses). After lab sessions, students should also sign out of the Amazon Web Services Console to avoid Single Sign-On (SSO) issues. Failure to sign out can lead to authentication challenges, hindering student access to resources in subsequent sessions. Reinforcing this practice ensures smooth authentication experiences and prevents unnecessary disruptions to their learning progress.

Identity and Access Management Limitations
While Identity and Access Management (IAM) customization is limited in the lab environment, this control mechanism mirrors real-world scenarios where most businesses segment jobs to protect their environments. Often, IAM is not controlled by those who are architecting or developing. They may assist in that process but typically do not have complete control. This can lead to situations where individuals must wait for others to complete their parts of the job, which can be frustrating but is a realistic aspect of working in a team.

However, roles have been created within the Learner Lab to perform some tasks. If role is needed to use a product or feature, it may already be provided. If not provided, educators may petition the AWS Academy for more access.

However, requests to remove platform limitations may not be approved. AWS Academy Learner Lab is constantly updated to give access to the latest AWS resources and address common challenges learners face. This dynamic nature of the content ensures that students are always equipped with the most current and relevant information.

Restrict Access to Resources

Instructors must explain how to secure resources. S3 buckets should restrict write access. Strong passwords or private keys should protect EC2 instances. Strong passwords and security policies should secure RDS instances. API endpoints should be restricted. AWS and Vocareum do not limit external connections to Learner Lab resources–that responsibility falls upon each student. In our experience, hackers have used students' unsecured resources for data exfiltration. Spikes in usage are often evidence of hacker usage in spending on S3, RDS, or EC2. Vocareum may terminate student labs if they detect indicators of compromise. In extreme cases, the Learner Lab course may be restricted from starting at the Vocareum level, affecting all students in the course.

Following the security principle of least privilege is difficult with Learner Lab IAM restrictions. Due to this limitation and students' lack of understanding of securing resources, additional security measures may be needed. A list of trusted IP address ranges, or an additional approval step to accept data from external sources may be used.

Serverless vs. Infrastructure

Serverless is a paradigm in which software functions are deployed without provisioning or maintaining the servers upon which those functions run. In the Learner Lab environment, serverless architecture avoids problems associated with creating and maintaining EC2 instances. Serverless is a good choice when students need to write code to meet business objectives.

EC2 instances follow a traditional computer architecture wherein servers are provisioned to serve client resources. Educators should use the traditional architecture when learning objectives emphasize infrastructure. Educators can leverage the Learner Lab environment to create web servers, database servers, directory servers, DNS servers, and other servers that mimic traditional data center environments.

Security Groups

The EC2 instance creation workflow defaults to creating a new security group for each instance. Instead of creating a new security group when launching EC2 instances, students should create security groups with meaningful names and descriptions based on EC2 server roles. For example, it might be prudent to have a "Public Web Server" security group that allows inbound traffic in ports 80 (HTTP) and 443 (HTTPS) from the public Internet.

Using consistent naming helps instructors troubleshoot security group problems. For example, Linux web servers might need port 22 open for SSH connections from a private subnetwork. When troubleshooting SSH connectivity to a Linux web server, the instructor could first check that the Linux web server security group was applied to the web server and then check if the security group has the appropriate inbound rules.

Network Segmentation

Network segmentation is a best practice for developing secure and performant networks. In AWS, a Virtual Private Cloud (VPC) can be divided into several subnetworks. Public subnetworks can reach the Internet through an Internet Gateway (IGW). IGWs are managed services provided by AWS at no cost. A sample network diagram is in Appendix C.

EC2 instances in private networks are not granted Internet access by default. However, they can connect to other EC2 instances in the same VPC. EC2 instances in private subnetworks cannot receive inbound connections from the Internet, which makes administering those instances using SSH or RDP more challenging. Systems Manager allows SSH and remote shell connections to instances in private subnetworks. However, a Windows bastion host is required to connect to private instances using RDP. Bastion hosts are described in the next section.

Bastion Hosts

A bastion host is used as the entry point for administrative purposes into a network. We recommend putting a Linux or Windows Server EC2 instance in a public subnet as the bastion host. We recommend a Windows Server when both RDP and SSH are required.

The bastion host's security group should allow inbound RDP traffic from anywhere online (0.0.0.0/0). Ideally, the inbound rules would only allow connections from specific IP addresses. However, because student IP addresses change frequently, the recommendation for restricting inbound connections to a particular IP address

becomes impractical. AWS provisions EC2 instances with unique, strong passwords. Students must protect the Administrator password and avoid changing it to something weaker.

NAT instances
NAT instances are virtual machines created in public subnetworks as proxies from private to public Internet. AWS officially endorses NAT instances as an alternative to its NAT Gateway managed service. Deploy the NAT instance as a small Amazon Linux EC2 instance in a public subnet. It should automatically obtain a public IP address and have a private IP address assigned statically. Private route tables should be modified to add a default gateway pointing to the NAT instance.

Static Private IP Addressing
By default, AWS assigns private IP addresses to EC2 instances automatically when the instances are provisioned. The IP addresses fall within the range defined by the subnetwork where the instance is deployed. However, two students could deploy instances in their respective private subnets and have instances with different private IP addresses. We recommend specifying a specific private IP address for the EC2 instances when provisioning for guided labs. Setting static private IP addresses helps students and instructors verify connectivity between servers, such as from a web server to a database server in a two-tier architecture.

Application Containerization
Installing applications on Linux can be challenging because software repositories, permissions models, and command-line tools may differ between distributions. Our experience shows that students struggle to follow vendor instructions to ensure their Linux platforms meet application requirements. Application containerization provides an abstraction layer on top of unique Linux distributions. Docker is a common platform for creating, deploying, and managing application containers. It is easier for students to install and deploy a Docker container than installing applications manually. Docker's learning curve is worth the investment.

User Data for Instance Customization
The EC2 launch wizard includes a text area for "user data." The user data is executed as shell commands, PowerShell scripts, or cloud-init directives when the instance is first initialized. These commands might install specific software, configure services, or set environment variables. For example, an instructor might provide students with a script to automate the entire Apache HTTP Server setup process so that students can start reaching learning objectives with minimal manual setup.

5. CONCLUSION

The AWS Academy Learner Lab environment is a powerful tool for educators to create realistic, flexible, and scalable learning exercises. Using the Learner Lab, students provision, manage and configure real computing environments.

Institutions must become members of the AWS Academy to leverage the Learner Lab environment. Instructors must complete asynchronous training to teach courses. Instructors should make students aware of key elements of the acceptable use policy as part of the course enrollment process, such as the prohibitions against mining cryptocurrency, storing sensitive data, or using the environment for commercial purposes.

Instructors should avoid paid managed services when designing course exercises, stick with recommended services (Appendix A), provide clear guidelines for security resources, and monitor students' environments. As with all learning platforms, the Learner Lab has its learning curve. We hope that the guidance in this paper helps educators avoid pitfalls and start teaching effectively using the Learner Lab environment.

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Appendix A: Key Learner Lab AWS Components

The AWS cloud offers a vast array of services. This section summarizes our recommendations for using these services based on our experience up to May 17 2024 using the AWS Learner Lab. As the Learner Lab is constantly updating, you should review the documentation as to what is available and can be used, including the limitations put on those services.

Endorsed Components

AWS Component: Simple Storage Service (S3)
Related Endorsed Services: Amazon S3 Select, Glacier
Shut down when lab session ends: No
Example Classroom Activities: Host a website, store backup files, store data for ML training, serverless application
Security Concerns: Secure S3 buckets to restrict write access from the Internet. Only allow read access from the Internet if required.
Helpful Resources:
Video - https://www.youtube.com/watch?v=P3xR3Fzezp8
Guide - https://docs.aws.amazon.com/AmazonS3/latest/userguide/WebsiteHosting.html

AWS Component: Elastic Compute Cloud (EC2)
Endorsed: Yes
Related Endorsed Services: Elastic File Storage (EFS), Elastic Block Store (EBS), Security Groups, Elastic Load Balancer (ELB), Auto Scaling Groups, Systems Manager (SSM), Amazon Machine Images (AMIs), Parameter Store, Elastic Beanstalk
Shut down when lab session ends: Yes
Example Classroom Activities: OS administration, application (installation, configure, maintain, secure), web application development, web server, scaling/clustering
Security Concerns: Key management, application passwords, patching
Helpful Resources:
Video - https://www.youtube.com/watch?v=1ueohGEr-14
Guide - https://docs.aws.amazon.com/AWSEC2/latest/UserGuide/option3-task1-launch-ec2-instance.html

AWS Component: Lambda
Related Endorsed Services: Application programming interface (API) gateway, DynamoDB, S3, Simple Notification Service (SNS), Simple Queue Service (SQS), Step Functions, CloudWatch, CloudTrail, Parameter Store
Shut down when lab session ends: No
Example Classroom Activities: Intro to programming, microservices, form processing, data processing and manipulation, API creation
Security Concerns: Due to the inability to use IAM, services need to be secured by other means if both accepting and displaying the accepted data. Least privilege should be implemented to the extent that it can. Inputs should be validated. Cross-Origin Resource Sharing (CORS) will need authorization
Helpful Resources:
Video - https://www.youtube.com/watch?v=fQ8Q_wWusYo
Video - https://www.youtube.com/watch?v=_s_tbELNFQs
Guide - https://docs.aws.amazon.com/lambda/latest/dg/getting-started.html

AWS Component: VPC
Related Endorsed Services: EC2, Relational Database Service (RDS)*, Security Groups, Network Access Control Lists (ACL), Subnetting, Availability Zones, ELB, Auto Scaling Groups
Shut down when lab session ends: No
Example Classroom Activities: Networking, subnetting, troubleshooting connectivity, service hardening, service deployment
Security Concerns: To secure services, we advise that security groups be as specific as possible

AWS Component: Cloud9
Related Endorsed Services: Cloud Formation, Command Line Interface (CLI), Code Wisperer
Shut down when lab session ends: Yes
Example Classroom Activities: Development, Infrastructure Automation
Security Concerns:

AWS Component: SageMaker
Related Endorsed Services: S3, Glue, S3 Select, Athena, Lambda, Jupyter Notebooks, Step Functions, Aurora, Code Wisperer, Data Pipeline, Elastic MapReduce (EMR), Kinesis
Shut down when lab session ends: Yes
Example Classroom Activities: Data Engineering, Extract Transform and Load Data, Use data in Data Analysis or Machine Learning
Security Concerns: Data should rarely be open to the world

Endorsed yet Cautioned Components

AWS Component: Elastic IP
Shut down when lab session ends: No
Example Classroom Activities: Web hosting, server management, service hosting
Concerns: Charged when not in use and EC2 shuts down when the lab ends, so you get charged when not in use.
Helpful Resources:
Video - https://www.youtube.com/watch?v=lJNtk0G4VCA
Guide - https://docs.aws.amazon.com/AWSEC2/latest/UserGuide/elastic-ip-addresses-eip.html

AWS Component: Instance Store
Shut down when lab session ends: Yes
Example Classroom Activities: Clustered systems local storage
Concerns: Should not be used on instances where data should survive reboot as the storage does not survive reboot. Storage is not persistent.

AWS Component: Lightsail
Shut down when lab session ends:
Example Classroom Activities: Pre configured lightweight applications for easy usage
Concerns: May shortcut some of the learning objectives of many courses.

Appendix B: Sample Onboarding Quiz Questions

Sample Onboarding Quiz Question 1
By providing your email address below, you certify that you will **not** use the AWS Educate Learner Lab to:

- Mine cryptocurrency
- Run for-profit services
- Host sensitive data (e.g., data subject to GDPR or HIPAA)

In addition, you will comply with the AWS Acceptable Use Policy and the AWS Responsible AI Policy. You recognize that a violation of these policies could result in AWS account deactivation and university discipline.

Your email: _____

Sample Onboarding Quiz Question 2 (Answers are bolded.)
Please check the boxes next to activities that are **prohibited** in the AWS Learner Lab environment:

- Creating virtual machines
- **Mining cryptocurrency**
- Deploying sample websites for training purposes
- Uploading randomized test data to a database
- **Storing sensitive data (e.g., data subject to GDPR or HIPAA)**
- **Running for-profit services**
- Creating public and private subnetworks

Sample Onboarding Quiz Question 3 (Answers are bolded.)
If the Learner Lab, or piece in it will not function what are some common reason why and how to troubleshoot them **(Please select the most correct answer)**

- The browser still has the session for a prior lab and is confused. Just need to log out of AWS and click to get in again.
- The terms of use needs to be accepted. Click on the link to get into where you can launch the lab again
- All of a specific resource has been used. Example you can only have 10 EC2 Instances running.
- Your lab has suspicious activity and is getting stopped. Look at the billing dashboard and see what prices are going up. Look to see how that service may be used by others in a nefarious way. Secure the service. You may also want to review logs and current system activity.
- All of the accounts funds have been used for the assignment or the course
- **All of the answers are correct**

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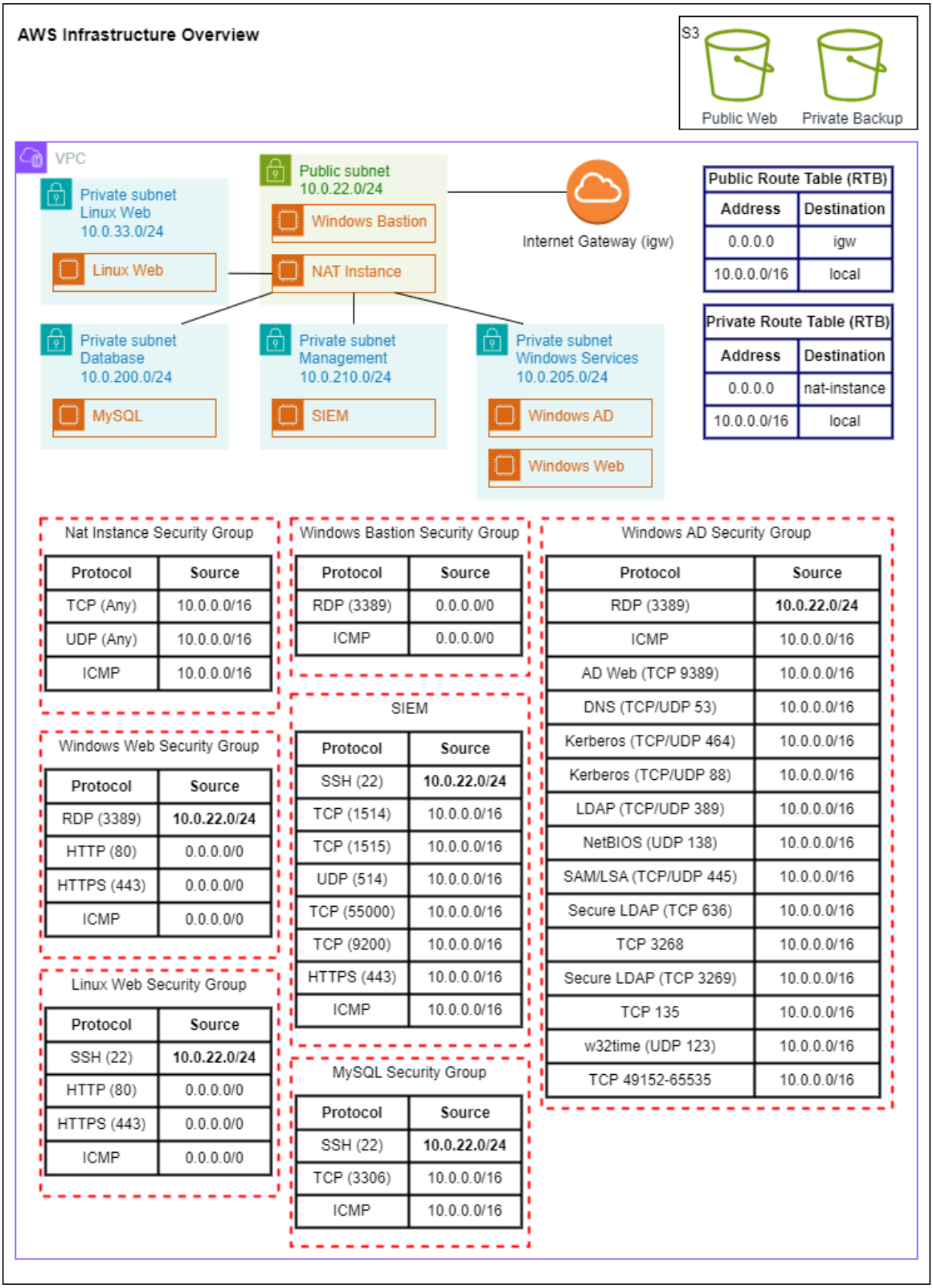
Appendix C: Sample Network Diagram

Below is a sample network diagram that shows how a cloud environment could be setup for learning exercises.



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Appendix D: Sample Course Sequencing