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INFORMATION SYSTEMS EDUCATION JOURNAL

Editors

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

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

Jeff Strain, Jim Marguardson and David Lee Gomillion

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 (Merchante et al., 2024; Segec et al., 2021; Qasem, 2019). 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). Whether in-house, by third parties, or in the cloud, hosting lab virtual machines 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 (Meyer & Billionniere, 2021).

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(Moltó et al., 2020). 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(Correia & Tasker, 2022).

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 providing 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 supports inclusivity by removing barriers, like a student who cannot afford a sufficiently powerful laptop to perform labs. The Learner lab lets students experiment with real-world information technology scenarios where they can destroy, create, and extend systems beyond classroom instruction. By working hands-on in cloud environments, students 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.

2. METHODOLOGY

The authors of this paper formed a quorum of experts. Their institutions include a public, research-intensive university, a private, undergraduate-focused university, and a public, regional, comprehensive university. The students at these universities have diverse socioeconomic backgrounds. The authors leveraged the AWS Learner Lab in many courses and collaborated to share their experiences. They identified common strengths and challenges using the AWS Learner Lab. The following sections contain actionable guidance the authors distilled from their experiences, augmented by the pedagogical literature related to teaching with cloud computing.

3. GETTING STARTED WITH THE AWS LEARNER LAB

This section describes how educators can start with AWS Academy and create Learner Lab courses. By necessity, this and subsequent sections refer to many different cloud technologies. A glossary of key terms is included in Appendix A.

AWS Academy Onboarding

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

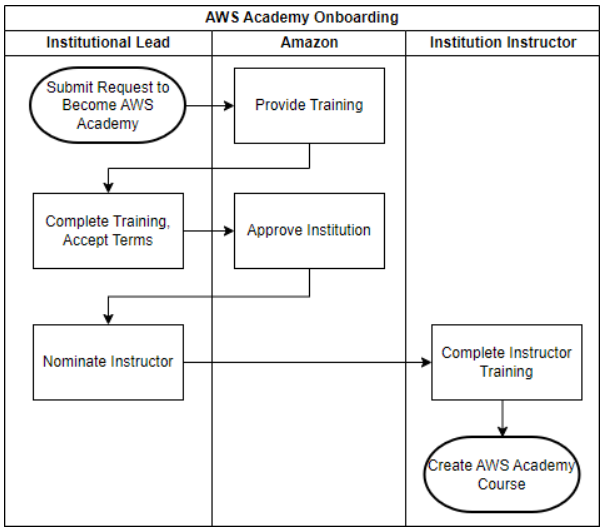


Figure 1 AWS Academy Onboarding Process

AWS Academy LMS

AWS Academy hosts all its courses using the Canvas learning management system (LMS). Instructors can create courses from the AWS Academy catalog. 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 provide custom instruction and labs.

Classroom Management

We recommend that educators create a Learner Lab section in the AWS Academy LMS for each university course offering. Segmenting courses limits the fallout if one section is decommissioned prematurely due to egregious violations. Educators should be aware that an entire Learner 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.

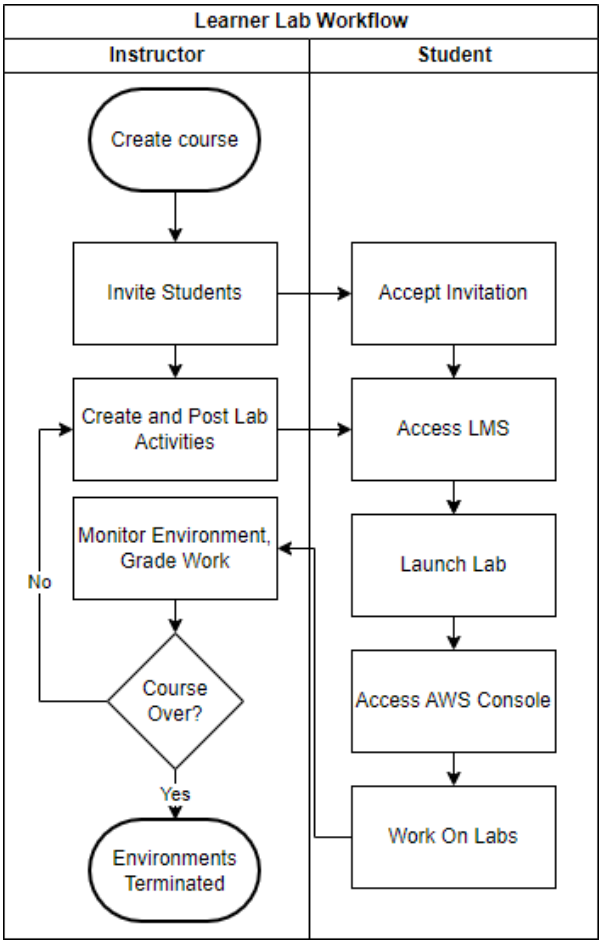


Figure 2 Classroom Management

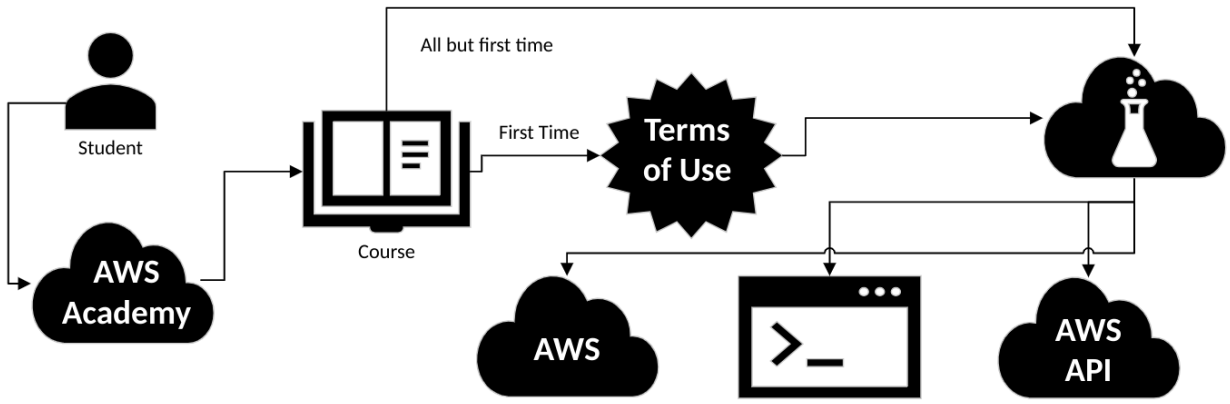
Before inviting students to an AWS Learner Lab environment, instructors should summarize key acceptable use policies before inviting students to a Learner Lab course and ideally require them to pass a quiz on those policies. A quiz (such as the sample in Appendix B) serves as a deterrent control and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

The AWS Academy LMS gives students an acceptable use policy on the first login. Most students scroll to the bottom of the policy and accept it without reading it thoroughly. However, specific uses of the Learner Labs (such as mining cryptocurrency) automatically trigger AWS Academy account deactivation.

If students will be enrolled 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 unavailable, 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.

The AWS Management Console (the website for managing AWS resources) uses cookies to maintain session state. Students registered in several AWS Academy Courses or with personal AWS accounts can experience confusion when accessing the Management Console.

Figure 3 Student Workflow



Educators should ensure students confirm the user identity displayed in the Management Console. All Learner Lab accounts will follow the username format "voclabs/user" followed by numbers. Accessing an AWS environment with the wrong account credentials will cause errors. To fix these errors, students must log out of the Management Console and re-launch the Learner Lab from the AWS Academy LMS.

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
Figure 3 Student Workflow

Vocareum is the bridge between AWS Academy LMS and the AWS cloud. When a student enrolls in a Learner Lab course, Vocareum provisions the student's AWS cloud environment with security keys and policies that grant access to many AWS resources. The Vocareum interface allows students to launch their environment, download SSH keys and credentials, access the AWS Management Console, shut down resources, and more.

A significant advantage of the Learner Lab (compared to students running labs on their laptops) is that the Vocareum interface allows instructors to monitor, change, or evaluate student workspaces. Instructors can remotely help students troubleshoot and fix 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 launching a Learner Lab session. Students can extend the session manually if needed. Extending the lab may result in power cycling the running EC2 instances and can change the public IP address. EC2 instances will not automatically be terminated (i.e., deleted) unless abuse is detected. 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.

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 a custom Amazon Machine Image (AMI), and students cannot provision virtual machines with many GPUs. The authors have distilled the Lab Foundations Service guide with a recommended set of useful AWS components in Appendix C.

The previous sections provided an overview of getting started with the AWS Academy, creating Learner Lab courses, and starting Learner Lab sessions. The following section describes how educators can use the Learner Lab to teach effectively.

4. PEDAGOGICAL SUGGESTIONS

The Learner Lab supports pedagogical best practices in the cloud. The Learner Lab promotes 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. This section discusses how educators can incorporate pedagogical best practices with the Learner Lab.

Consider the Real-World Impact
Students need context to understand the technology and its importance. Students should explore real-world applications of AWS skills beyond the classroom. When students research cloud computing job opportunities, they gain valuable insights into the relevance and high demand for cloud computing expertise (Chen et al., 2012). This perspective will motivate students to apply themselves to learning cloud computer skills in the Learner Lab because the post-graduation benefits will be clear.

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; Podeschi & 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 Appendix D for a sample of 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 (Chen et al., 2012; Flood & Hall, 2022; Mew & Money, 2018; Milošević et al., 2022; Pike & Brown, 2019).

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.

Custom Lab Materials
Amazon constantly updates and expands the AWS cloud. The Learner Lab gives access to the current AWS offerings. Instructor-created lab guides may need to be refreshed periodically. To reduce the maintenance burden, consider leveraging rich media, such as videos, to help students (Goteng et al., 2022; Nasim et al., 2021; Sablić et al., 2021). Students may be better served when encouraged to find helpful videos rather than providing specific ones (Almuslamani et al., 2020).

Building Scaffolded Learning Experiences
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 gives students access to tools that allow them to create solutions 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 (*guided labs*), labs that leave some details up to students to figure out (*challenge tasks*), and finally new an original projects that students can create (*independent projects*).

Guided Labs
In Guided Labs 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. Guided labs align with the "remember" and "understand" levels in Bloom's taxonomy. Challenge tasks align with the "apply," "Analyze," and "Evaluate" levels of Bloom's taxonomy.

Challenge Tasks
With challenge tasks educators 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
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. For example, a student used the Learner Lab to test technologies for a master's thesis (Morales Muñoz, 2024). Independent projects align with the "create" level of Bloom's taxonomy.

The Learner Lab supports educators' efforts to teach effectively. Cloud computing is complex. In the following section, we provide technical recommendations that help educators achieve learning outcomes while minimizing technical complexity.

5. LEARNER LAB TECHNICAL BEST PRACTICES

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.

Option 1: Use Vocareum's Key Pair
Vocareum provisions each student's Learner Lab environment with a new key pair. Students download their public and private keys in the Learner Lab LMS. If students lose their key pairs, they can redownload their keys from the LMS. Relying on Vocareum's keys makes it easier for students to maintain access to their resources.

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 a 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 expensive AWS 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 network address translation (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, Virtual Private Cloud (VPC), Internet Gateway (IGW), and Simple Storage Service (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. 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 Learner Lab credit provided 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 single, small server. In another case, a student showed the faculty member a pricing estimate for the CloudWatch logging that would cost more than USD 100.00 per month. By reducing the number of logged items the learning outcomes were achieved 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 Learner 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 hourly charges. 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.

Identity and Access Management
The AWS cloud provides fine-grained Identity and Access Management (IAM) control. The Learner Lab restricts access to many IAM features. A lab role that grants access to AWS features is instantiated in each Learner Lab environment and has access to many AWS resources. In some cases the lab role may lack sufficient access to the AWS resources needed to perform a task.

Educators may petition the AWS Academy for more access, but requests to add access may not be approved. Educators must test lab instructions in the Learner Lab because an activity that worked may now require features disabled by IAM policy in the Learner Lab.

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 managed appropriately. The Learner Lab does not limit external connections to AWS resources. Limiting access 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, an entire Learner Lab course may be temporarily disabled, 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 and show data from external sources may be used to hinder hackers from using student-developed applications for data exfiltration.

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.

Educators should use the traditional server-based architecture with EC2 instances 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 VPC can be divided into several subnetworks. Public subnetworks can reach the Internet through an IGW. A sample network diagram is in Appendix E.

Because they lack public IP addresses, 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 Secure Shell (SSH) or Remote Desktop Protocol (RDP) more challenging. AWS 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, otherwise, the bastion host could be compromised.

NAT instances
NAT instances are virtual machines created in public subnetworks serving as proxies from private subnets to the 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. In our experience, teaching students to deploy applications via Docker takes less time than teaching students to install application-specific dependencies and code. Docker has proven to streamline application installation and management (Dubec et al., 2023; Sakshi & Dutta, 2024; Tambi & Shin, 2024).

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.

Collectively, these technical best practices have allowed us to create repeatable, effective lesson plans that help students succeed in the Learner Lab.

6. 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 AWS Academy 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.

Lab exercises should avoid paid managed services, stick with recommended services (Appendix C), and provide clear guidelines for security resources. Throughout a course, educators should 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 Terms and Definitions

AWS Academy – An educational program that provides a cloud computing curriculum combined with practical learning experiences to educational institutions.

AWS Management Console – A web-based graphical user interface that allows users to monitor, configure, and manage cloud services.

Bastion Host – A secure server placed in a public-facing network to act as an access point for managing systems within a private network.

Cloud Computing – An information technology model that enables users to compute power, storage, and applications without relying on local hardware.

CloudFormation – A service that automates the setup and management of cloud resources using predefined templates.

Containerization – A method of packaging software and its dependencies into a standardized unit, ensuring it runs consistently across different environments.

Docker – A tool that enables the deployment of applications in lightweight, portable environments called containers, improving consistency across systems.

Elastic Compute Cloud (EC2) – A service that provides resizable virtual servers to run applications in the cloud.

Elasticity – The ability of a cloud system to adjust to demand by scaling resources to match.

Identity and Access Management (IAM) – A security framework that manages user permissions and access to cloud resources.

Infrastructure as a Service (IaaS) – A cloud model where virtualized computing resources such as storage, networking, and servers are provided on demand.

NAT Gateway/NAT Instance – A service that enables instances in a private network to access the internet while preventing inbound traffic from external sources.

Platform as a Service (PaaS) – A cloud model that provides developers with a managed environment to build, deploy, and manage applications without physical infrastructure.

Private Subnet – A segment of a network that is isolated from direct internet access used for securing internal systems.

Public Subnet – A network segment allowing resources to communicate directly with the internet.

Security Groups – Configurable rules that define allowed and restricted traffic for cloud-based virtual machines and services.

Serverless Architecture – A computing model where applications run in the cloud without requiring users to manage the underlying infrastructure.

Serverless Computing – A cloud-based execution model where applications scale automatically, and users are only billed for the resources they consume.

Simple Storage Service (S3) – A scalable cloud storage solution allowing users to store objects and retrieve them virtually anywhere.

Software as a Service (SaaS) – A cloud model where applications are maintained by a third party and accessed through the web, eliminating physical infrastructure and the need for skilled people to maintain the software.

SSH Key Pair – A pair of cryptographic keys used for securely authenticating access to cloud-based systems and services.

Virtual Machine (VM) – A software-based simulation that represents a physical computer.

Virtual Private Cloud (VPC) – A logically isolated network within the cloud where users can define and manage their networking configurations.

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**

Appendix C: 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 March 2025 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.

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:

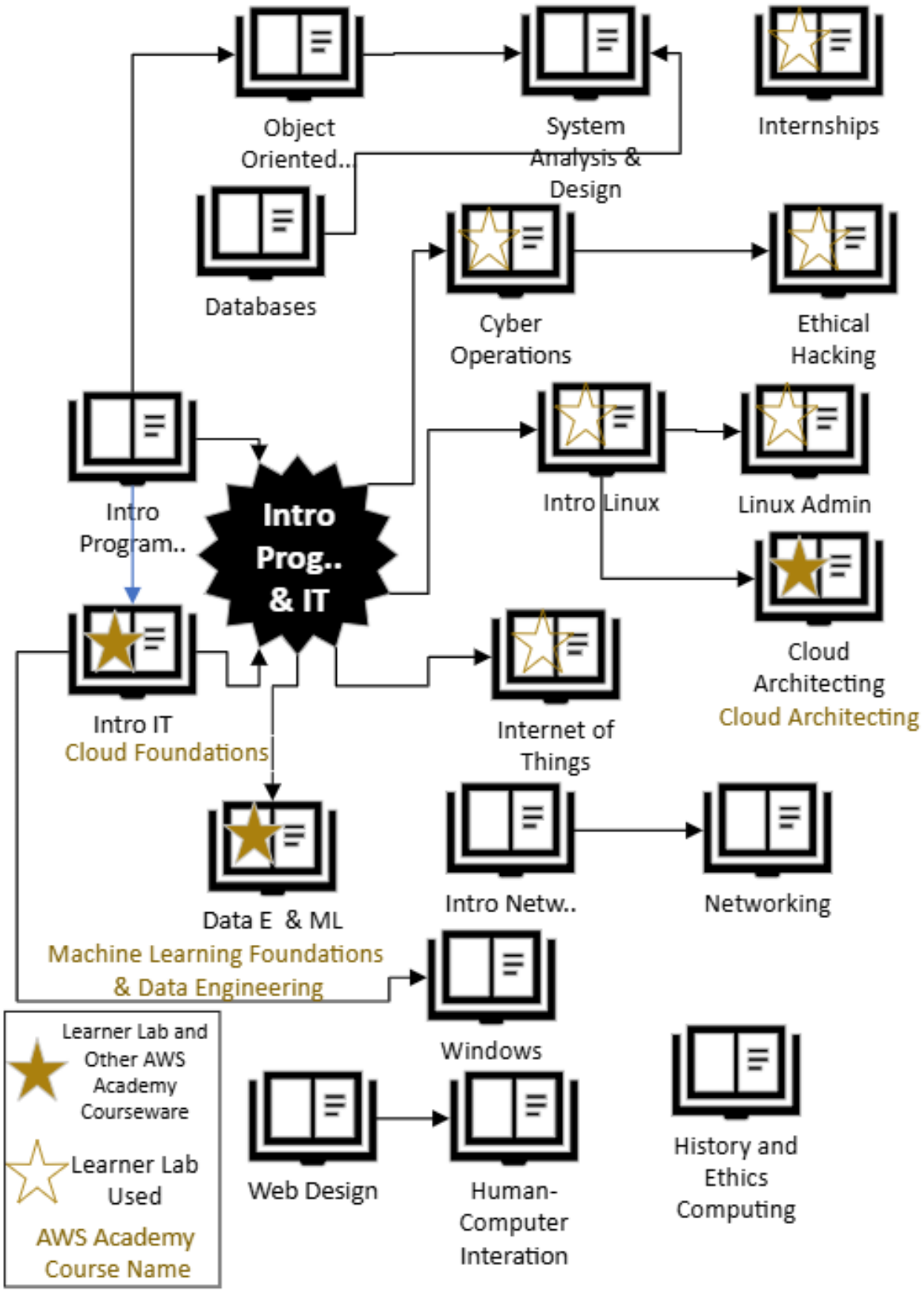
AWS Component: SageMaker
Related Endorsed Services: S3, Glue, S3 Select, Athena, Lambda, Jupyter Notebooks, Step Functions, Aurora, Code Wisperer, Data Pipeline, Elastic MapReduce (EMR), Kinesis
Shut down when lab session ends: Yes
Example Classroom Activities: Data Engineering, Extract Transform and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

AWS Component: Elastic IP
Shut down when lab session ends: No
Example Classroom Activities: Web hosting, server management, service hosting
Concerns: Charged when in and not in use. If assigned to an EC2 that shuts down when the lab ends you will get charged for the IP address. This can quickly add up over a semester. Use caution when using Elastic IP addresses.
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 D: Sample Course Sequencing



Appendix E: Sample Network Diagram

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