

Introducing the Cloud in an Introductory IT Course

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Abstract

Cloud computing is a rapidly emerging topic, but should it be included in an introductory IT course? The magnitude of cloud computing use, especially cloud infrastructure, along with students' limited knowledge of the topic support adding cloud content to the IT curriculum. There are several arguments that support including cloud computing in an introductory course. In light of this, several cloud computing activities based on the Amazon Web Services (AWS) cloud offerings were added to an introduction to IT course. Student and instructor perceptions of the activities and the AWS service are evaluated and future plans are discussed.

Keywords: Cloud Computing, IT Education

1. INTRODUCTION

Teaching an introductory course in an IT curriculum presents several challenges. There is an abundance of content that supports later classes in the course of study and the course also needs to accommodate students with a with a range of previous experience and knowledge. Additionally, the course needs to have content to explore the wide range of career options for IT professionals and prompt students to start developing longer term plans for making use of the IT knowledge they are acquiring. Finally, with the constant evolution of technology, the course needs continuous updates to include new technologies while avoiding the latest fads that end up being hype without substance.

This paper discusses an effort to update an introductory IT course to add content on cloud computing. Specifically the added content was intended to provide students with experience working with cloud based infrastructure and also show how cloud offerings affect strategic aspects of IT decision making. The AWS Educate program was used to in course assignments and is also evaluated.

Students had little prior knowledge of cloud computing and were surprised to learn how widely cloud infrastructure is used and found that companies they recognize are making significant use of cloud infrastructure. Students reported strong agreement that the cloud computing content and assignments helped them learn about the cloud and should be included and possibly expanded in future offerings of the course. The AWS Educate program was also found to provide good resources to support the cloud computing content in the course.

2. BACKGROUND

Cloud computing is widely discussed, with mainstream media suggesting that "2015 is, by all appearances, the year that the enterprise cloud is turning into a huge market."(Kelleher, 2015). But should it be covered in an introductory IT course? There are many facets to this question – will the students see the value of the material, does it fit with other course content, will it give students knowledge that employer's want, does it fit into the department's curriculum? Many factors should be considered in this decision. To start with, is the cloud going to have a permanent impact on IT, or will it be another passing fad?

Amazon Web Services (AWS) reported \$3.66 Billion of revenue in the first quarter of 2017 (Krazit, 2017). Estimates of the number of servers in AWS data centers are in the range of 2.8 million to 5.6 million (Morgan, 2014). Looking at cloud offerings that students may be more familiar with, sixty-one (61) of one hundred (100) top universities are using Google Apps for Education (Mills, 2011). Netflix, a leading video streaming service, has recently completed migrating all of the infrastructure supporting their service to the cloud (Izrailevsky, 2016). These and many more examples indicate that cloud software and infrastructure has become a core part of the IT world

Another factor to consider when adding content to an introductory IT course is whether it will support other courses in the curriculum. Ideally, material in the introductory course will provide an introduction to support more detailed exploration of topics in later courses.

Rehman, et. al. (2015) provide a useful review of cloud computing courses. They find a mix of dedicated courses focusing on how cloud computing works or using a particular cloud based tool and more traditional courses that make use of cloud tools or infrastructure.

In a study comparing the use of cloud-based versus local-based infrastructure to support a web development course, Pike, Pittman, & Hwang (2017) noted that students using cloud-based infrastructure "encountered greater difficulties than anticipated in gaining proficiency with the technology." As they note, this could be addressed by providing a cloud computing introduction in the web development course or in a pre-requisite course.

Lawler (2011) notes that cloud computing connects to many aspects of the IS 2009 Curriculum Model, and presents a model program with significant cloud computing content in the first year of study. Lawler also makes an interesting observation about the impact of cloud computing on the culture of organizations, including internal IT organizations, and proposes addressing change management aspects of cloud computing in the first year of the IS program. Both of these support introducing cloud computing early in the curriculum.

In reviewing our current curriculum, cloud infrastructure or tools could be used in several courses including networking, database, security, web development, and capstone courses and

there are existing examples of cloud use in all of these courses. This consideration also argues for including cloud computing content in the introductory IT course.

In considering whether cloud computing fits with the department's curriculum, there were some arguments that it was not a good fit. These were based on the view that cloud computing hid too many details. For example, students using cloud servers would not have to know how to build servers and install operating systems from scratch. There were also arguments that the cloud was too automated. There is value to these arguments, but they must be balanced with the numerous arguments for adding cloud content. To address these concerns, extra attention was given to discussing the strengths and weaknesses of the automation and standardization enabled by cloud technologies.

A final consideration before concluding that cloud content should be added to the course is the possibility that students will have previous knowledge on the topic, which would reduce the necessity for adding the content. Casual discussions with students and observation of the technologies used by students show that they actively use a wide range of tools, apps, and services that use cloud infrastructure. However, the cloud infrastructure is hidden from the end users, so students are not aware that they are making use of cloud computing. As Serapiglia (2013, p. 58) notes "students that I found in my class room were walking in knowing that magic was occurring, and not knowing how." This offered the opportunity for discussions that revealed the "magic" of software and services that students regularly used.

Having concluded that there is value in adding cloud computing content to an introductory IT course, the next questions are what the content should cover and what cloud tools should be used.

Recent efforts have considered a number of different tools including locally run clouds (Hwang, Pike, & Mason, 2016) that would provide a wide range of opportunities for students to design, configure, and manage clouds in addition to using them. However, this may involve significant costs and technical support. For smaller institutions with fewer resources, a public cloud like Microsoft Azure offers another option (Mew, 2016).

At the time these course revisions were being developed, Amazon's AWS Educate (AWS

Educate, n.d.) program was relatively new. AWS Educate offers access to a wide range of cloud infrastructure and provides small grants of AWS resources to instructors and students to support these. The opportunity for the instructor to further explore the AWS Educate program combined with free resources for students made this a reasonable choice. An added benefit was that the university's LMS used AWS infrastructure allowing discussion of how this benefitted students.

In considering the content to add, the previously discussed idea of supporting other courses in the curriculum was kept in mind along with relating the new content to other existing content in the course. Using these considerations, content on using cloud servers seemed most appropriate. This could be related to existing course content on operating systems and Linux and would support networking, web development and capstone courses. In addition, students would gain experience working with the AWS Management Console which would be useful for use of any AWS tools in later courses.

In addition to providing students hands on experience working with cloud infrastructure, content and activities to help students see how the flexibility, scalability, and elasticity of cloud infrastructure can affect strategic IT decision making was also seen as important content to include. Since the course already had content to introduce IT strategy and decision making, this would extend existing course content.

3. THE COURSE

The Computer and Information Technology Department at (removed for review process) University offers several degree options. At the bachelor's level, students can earn a degree in Information Technology or a focused degree in Health Information Technology. Several associate degrees are also offered.

Two courses serve to introduce students to the field of Information Technology. These Introduction to IT courses provide students a broad overview of the IT field and are required for all IT degrees. The content of the two courses is structured to allow students to take the courses independently and in either order. The course described in this paper introduces a range of topics including computer architecture, data representations, operating systems, a survey of programming languages, and the wide range of tools used by IT professionals. The course

focuses on problem solving in an IT context, including algorithms, analysis, development, testing, and documentation. To highlight the importance of problem solving, an effort is made to use problem solving in as many contexts as possible. For example, the discussions of programming languages and IT tools include the concept of picking the appropriate language and tools as an IT problem.

In addition to introducing students to a number of fundamental technical concepts, an important part of the course is introducing students to the IT profession. Students have many motivations for entering the IT major – previous experience with programming, experience working with computer hardware, recommendations from friends or relatives, interest in writing games, etc. Providing a clear idea of what IT professionals do (and do not do) is also part of the course. This is done through a variety of activities. One activity starts on the first day of class with a discussion of the people, places, and things in IT. These discussions are used to discover student's current knowledge of job titles and work activities (people), work locations and environments (places), and objects (things) that involve IT professionals. These were documented and referred to throughout the semester. The discussion concluded with the instructor identifying any gaps in the items identified by students. A follow up activity asked students to review local IT job postings, select one to post to an online discussion board, and review and comment on items posted by other students. This activity allowed students to start exploring jobs that matched their interest and also exposed them to the variety of skills required for IT positions.

A recurring class activity discussed current events in IT. Each student was assigned a specific class period where they were responsible for finding an article for discussion. Students posted the article in the online Learning Management System (LMS) before class and commented on why they found the article interesting. The student then introduced the article to start an in class discussion. Another student was assigned to post a summary of the in class discussion to the LMS and students were encouraged to continue the discussion online. Selected articles typically cover a broad range of topics, which serves the goal of helping students understand the breadth of the IT profession.

Since this course is a key part of the IT curriculum, it is offered every semester. The

particular course session discussed in this paper was taught in a fully face-to-face setting where the class met for two hours and fifty minutes once a week. For the course section discussed in this paper, the initial course enrollment was seventeen (17) students, with fourteen (14) completing the class.

4. CLOUD COMPUTING ACTIVITIES

The course activities that introduced students to cloud concepts occurred towards the end of the course. This allowed the cloud computing material to build on previous material including an introduction to problem solving using the Python programming language and an introduction to the Linux operating system.

The cloud activities were designed to use the same approach as other activities in the class. This approach recognized that introductory classes give students an initial experience with a topic, with many details left for discussion in later courses. To achieve this, assignments were structured with a destination and journey approach. Students were given detailed steps for completing an activity (the destination), but were asked to submit a written discussion of their experience with each step along the journey. For example, in earlier Linux activities, students were given the Linux command needed to complete a task, but needed to consult the documentation (man or info pages) to find needed arguments or interpret output. For some steps, specific writing prompts were provided. For example when they executed the Linux command "cal 9 1752" (which displays the calendar for the month when 10 days were removed as Great Britain switched from the Julian to Gregorian calendar), students were asked if they noticed anything odd, and asked to find an explanation (which could be found in the documentation).

All cloud activities made use of the Amazon Web Services (AWS) cloud so that students could take advantage of the AWS Educate program that provided each student credits that for AWS usage along with training and tutorials. Another value in making use of AWS was that the wide range of companies using AWS included a number that were familiar to the students. These included Netflix, online gaming platforms, and Canvas (the LMS used in the course).

AWS Introduction and Account Setup

The first activity was intended to familiarize students with AWS and complete the account setup process. The activity provided detailed

instructions to walk students through the process of applying to AWS Educate and creating an AWS account. After a few days, the students AWS Education applications would be accepted and they received a code they applied to their account to receive a \$100 credit. Students did this activity a week before activities that used AWS to allow time to receive the credit and resolve any account issues.

The activity also tasked students with reviewing the products offered by AWS. Students were explicitly directed to the details and pricing of the Elastic Compute Cloud (EC2) since this product would be used in later activities. Students also reviewed the AWS case studies (Amazon EC2, n.d., Case Studies, n.d.) to look for companies they recognized and watched the video from at least on case study.

To make students aware of resources they could use to learn more about AWS, they reviewed the AWS Training and Certification details, and completed the self-paced lab for EC2 (AWS Training, n.d.). To record their participation in this activity, students submitted a one paragraph written discussion covering what they learned about the AWS products, AWS case studies, and AWS training activity.

Using Python on AWS

The next activity using AWS built on an assignment from the Linux operating system module. In the Linux activity, students worked on a Linux server where Python 2 was the default version of Python and had to locate and make use of Python 3 to run a Python program both as a command line argument to the Python interpreter and as a standalone Linux executable.

The Linux assignment introduced the fact that different operating systems use different line terminating characters in text files. Students used Linux tools to identify and fix end of line termination issues with Python files uploaded in a Windows format as part of the process to run the Python program as a standalone Linux file.

The students were asked to complete the same task using AWS, which added the need to create and connect to an EC2 instance using a specified Linux Amazon Machine Instance (AMI). Students had seen the process for creating and connecting to an EC2 instance in the self-paced lab completed in the first activity and were also walked through the process in class, so this process was not completely new to them.

Once the students had started and connected to the EC2 instance, they were told to complete the steps used in their previous assignment. However, the specific Linux AMI that students used was selected to introduce an additional complication to their journey. The specific AMI provided a Linux environment similar to the one used in the previous Linux assignment in having both Python 2 and Python 3 installed, with Python 2 as the default version. However, it did not have the dos2unix tool used to convert text file line encodings installed. When students tried to use this command they got a message that it wasn't installed along with a suggestion on how it could be installed. Students were asked to explore the suggested command and determine what source would be used to install the software. Students then executed the suggested command and completed the activity.

In addition to introducing students to starting and running an AWS EC2 instance, this activity also provided insight into how software updates and installations for an AMI are configured. It extended the Linux content to allow students hands on experience in performing Linux system administrator tasks. Linux system administration was discussed during the Linux module, but due to the potential risk of disruptions to the physical Linux server being used, hands on experience was not possible.

Using AWS to Install a Web Server

The final hands on cloud assignment asked the students to use an EC2 instance to install a web server. This activity served many purposes. First, it showed students that a task they might expect to be complex and time consuming could be greatly simplified by starting from an Amazon AWS EC2 instance. It also introduced students to the security aspects of EC2 instances. Finally, it showed students some of the details behind the web sites they interact with on a daily basis.

For this activity, students started an EC2 instance using a Linux AMI and connected to the instance. They used system administrator access to run two commands to install and start the Apache HTTPD server. They also used process monitoring commands introduced in the earlier Linux module to ensure that the Apache server actually started. For several of these steps, students were given specific reflective prompts that required them to explore on their own. For example, before running the command to install the Apache HTTPD server, they were prompted to determine exactly what would software would be installed,

what site would it be installed from, and did they think this was a source they would trust?

Next students used a web browser to access the server. This actually didn't work and resulted in a page not found error. Students were directed to find and review the default security group created for their EC2 instance to see if they could identify the problem. Once they identified that the default security group blocked all HTTP traffic using port 80 on their EC2 instance, they were able to add a security rule allowing inbound HTTP traffic.

When this was successfully completed, students were able to view the default Apache successful installation page. This page provided information for a website administrator about where to add content. Students were directed to create a simple HTML file and load it to their web server. While attempting this, students encountered another issue they needed to understand and address. The issue was a common Linux issue of not having write access to a directory and students needed to use the "sudo" command to overcome this issue.

In addition to providing a screen shot of their HTML file being displayed, students were also asked to reflect on the activity. Specifically, they were asked to explain what the commands provided to install the Apache HTTPD server would do, what source would be used in installing the software, whether they thought it was a trustworthy source, how they resolved the issue with the security group, and how they resolved the final file access problem. Finally, the students were asked to reflect on whether the process was easier or harder than they initially expected.

AWS Cost Estimating Case

The final assignment involving AWS involved a case study that helped students explore how cloud infrastructure like AWS impacts cost estimating and decision making processes for procuring IT infrastructure.

The case involved the need to replace a Linux server that was used to support a data mining course at a college. Students were presented information about the computing and storage capacity of the current server and asked to create a cost estimate for using AWS EC2 to support the class.

This task helped students learn about the different pricing options for AWS products. For the server, EC2 offers on-demand pricing with a

set charge per hour of use and also offers reserved instances with different payment options and the potential for significant price reductions if the customer can commit to a year long term (Amazon EC2 Pricing, n.d.). With storage using AWS Elastic Block Store (EBS), there are similar choices based on storage performance (Amazon EBS Pricing, n.d.). Students had to explore the details of these pricing options to prepare the cost estimates.

The initial scenario presented in the case was for a course with an enrollment of 24 students. After students had developed a cost estimate for using AWS to support this scenario, additional scenarios were presented. These included supporting multiple sections of the course in a term and also a single course section with a lower enrollment. Students were also asked to develop their own scenario to explore. Students developed cost estimates for using AWS for all of the scenarios. In addition to a potential cost savings, student were also asked to write a paragraph discussing reasons other than cost for why using AWS might be a better solution.

Exploring the additional scenarios let students see the flexibility and scalability offered by AWS. For example, if a second section of the course was added, the needed AWS resources would be available immediately while it might take several weeks to procure additional physical infrastructure resources.

5. EVALUATION

At the end of the term, a reflective assignment was used to get student feedback on the cloud content and assignments used in the course. The goal of the reflective assignment was to get student input on whether they found the content useful, whether the content should be included in future sections of the course, and suggestions for improving or expanding the content. The first part of the reflective assignment had four survey questions and the second part of the assignment asked student to provide a written reflection on their experience working with AWS.

The survey portion of the assignment asked four questions. The first two used a 5 point Likert scale asking student to agree or disagree with the statements:

- I found the discussion and activities related to Amazon Web Services (AWS) helpful in learning about the cloud computing technology.

- I saw the value of discussing and working with AWS.

The next question asked students to use a 7 point scale to score how much they enjoyed the discussions and assignments related to AWS. The final question asked for a yes/no response about "Should the discussion and assignments using AWS be continued in further sections of this course?"

In the written reflection portion of the assignment, students were asked to address a few specific points and provide any other comments they had. The specific points they were asked to address were:

- What was the most surprising thing you learned about AWS?
- What was your favorite part of learning about AWS?
- How effective were the assignments for learning about AWS?
- What aspects of AWS would you have liked to learn more about?
- If you were teaching the course, what would you do differently for the AWS discussions and assignments?

Of the fourteen (14) active students, eleven (11) submitted the AWS reflection assignment. The three (3) students who did not submit the reflective assignment also did not submit any of the AWS assignments.

The responses to the survey questions indicated that all of the students found the AWS discussions and assignments to be helpful, with the majority (7 of 11) strongly agreeing. Results for the question about whether the student saw the value of the AWS discussions and assignments were similar, with all agreeing and the majority (8 of 11) strongly agreeing.

Responses to the question "How much did you enjoy the discussions and assignments related to AWS (1 = Not Very Much to 7 = Very Much)?" were again all positive, with the average of the responses being 6.1. Finally, all of the students agreed that the AWS content should be continued in future sections of the course.

Students submitted a wide range of comments for the written reflection questions, but several themes could be identified. For the question about what was most "surprising," several students noted that they were surprised to learn that AWS exists and is a significant part of what Amazon does. Most were also surprised by the

extensive range of products and options offered through AWS. A number of students were also surprised by the wide range of companies, especially larger companies like Netflix that use AWS.

For the "favorite" part of learning about AWS, almost half of the students mentioned the assignment to setup a web server using AWS. They enjoyed learning more about how a web server works, and were surprised at how easy the process was using AWS. Another theme mentioned by several students was just learning about the wide range of products offered by AWS and the different ways that companies make use of the AWS offerings.

For the question about "How effective" the assignments were, all of the students found them to be effective. Several made positive comments about the breadth of the assignments and the ability to get hands on experience with AWS.

The question about the aspects of AWS they would have liked to learn more about generated a range of responses. Several responses showed interest in more in-depth exploration of the EC2 offering by creating multiple servers that interacted or exploring the capabilities to scale resources up or down. The other responses showed an interest in expanding the breadth of the topic, with specific mention of security and identity management. All of the comments provide good ideas for expanding the cloud content in the course.

For the final question about "If you were teaching the course, what would you do differently for the AWS discussions and assignments?" the most common suggestion was to spend more time on the topic. Two other interesting suggestions were offered. One student suggested that after the introduction to AWS, students could vote on what AWS offerings should be explored in more depth. Another student suggested making more use of the hands on labs provided through the AWS Educate program.

The AWS Educate offering proved useful for the course. A couple of students had minor issues with the registration process, but these were resolved and did not prevent students from completing the AWS Introduction assignment on time. A couple of students reported problems in completing the self-paced lab on EC2, but these issues were easily resolved. One of the perceived values of the AWS Educate program is the \$100 credit provided to students. At the end of the

course, students were reminded of the credit and the AWS Educate training resources and encouraged to explore more AWS products.

6. CONCLUSION AND NEXT STEPS

The main conclusions that can be drawn from the assessment of the cloud content and assignments piloted in this course are that students saw the value in learning about cloud computing and found the specific discussions and assignments helpful in learning about cloud computing. The content clearly helped students understand more of the "magic" behind software and services they use on a daily basis.

The written comments students offered expressing surprise on learning about AWS, its scale, and their recognition of a number of the companies using it were also expressed in class discussions. This supports that idea that IT students need to be aware of the impact that cloud computing is having, and that size of AWS makes it a good choice for introductory activities.

From the instructor's perspective, the student feedback from the reflective assignment along with their enthusiasm shown during in class discussions and in submissions for the AWS related assignments validates the decision to add this content to the course. The lack of problems, breadth of offerings, and supporting labs and tutorials confirmed that AWS Educate was a good platform to use for these activities.

For future offerings of the course, the cloud content will be extended. The most likely addition would be content that demonstrates the elasticity of cloud offerings. Letting students select additional content to explore is also being considered, possibly as a group assignment with each group exploring a different topic and sharing what they learn with the rest of the class.

Another idea that is being considered is to combine the Linux and cloud computing content. There is a natural affinity between the two, and the wide range of EC2 instance types and Linux and AMIs would allow assignments to explore a wider variety of Linux flavors and server configurations than is possible with the physical server currently used in the Linux module. Additionally, the availability of Windows AMIs would allow students to see a wider range of operating systems (Windows Server on AWS, n.d.).

A couple of other long term ideas are also being developed. One is to identify other courses in our curriculum that could make use of AWS Educate resources and cover topics in the cloud content of the introductory course that will prepare students to make further use of AWS offerings in the later course. The idea of expanding the content into a full course is also worth exploring. Finding room in the curriculum may be a challenge, but covering the cloud in a special topics course could be an interim solution.

In conclusion, while adding new content to a course is a risk, with unpredictable results, the outcome in this case exceeded the instructor's expectations.

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