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Expanding Literacy's Boundaries in K-12 with Cloud Literacy (Work in Progress)

Dr. Elodie Billionniere, Miami Dade College

Dr. Elodie Billionniere is an Associate Professor in the School of Engineering and Technology at Miami Dade College (MDC). She has helped MDC secure over \$3 million in federal funding the past three years for STEM and emerging technology education programs as well as a collaborative high tech learning hub, Cloud Computing Center, with the aim of providing further opportunities to minoritized populations to meet workforce needs. With industry partners, she has been instrumental in the creation of new educational pathways in Enterprise Cloud Computing, which are unique in the state of Florida. She is the Lead Faculty for these programs. She holds several industry certifications, including PMP, ScrumMaster, AWS Certified Solutions Architect, and AWS Certified Big Data. She holds a Ph.D. in Computer Science from Arizona State University.

Prof. Lawrence Eric Meyer Jr., Miami Dade College

Mr. Lawrence Eric Meyer is an Associate Professor Senior in the School of Engineering and Technology at Miami Dade College (MDC). He has been working as the Co-PI on the Dade Enterprise Cloud Computing Initiative (DECCI) cloud grant providing cloud educational opportunities to high school and minority underserved populations. He assisted in the creation of MDC's current cloud curriculum and has been awarded a \$600,000 ATE NSF grant to create an advanced cloud degree program for upskilling and reskilling the regional workforce. Holding AWS Solutions Architect and Developer certifications, along with Azure and Google cloud he is leading the effort into multi-cloud implementations for education in DevOps and Data Analytics.

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Abstract

The migration of infrastructure from on premise installation and maintenance of computing resources to cloud based systems by business of all sizes has been an ongoing event for several years. To minimize capital expenses and allow for demand based operational expenses has increased the need for cloud practitioners with the ability to create and control these resources. The demand for skilled cloud workers ranging from developers to architects has been increasing, and one way to increase the technicians available for these job skills is to start recruitment as early as high school. For high school students interested in the technical side of STEM pathways, the ability to understand, design and work in a cloud environment is now part of critical technical skills. Fluency in cloud and cloud environments, the ability to understand the capabilities of all these modern technologies are necessary technical skills.

To support this growing demand of cloud skills, Miami Dade College partnered with Amazon Web Services (AWS), the industry leader in cloud computing solutions, to train high school students as early cloud adopters and to be well-prepared for the computing/IT workforce of tomorrow. This academic-industry partnership aims to raise cloud literacy in K-12 by offering a two-week cloud computing bootcamp, Cloud 101, for high school students selected from traditionally underrepresented groups, Hispanic and/or African Americans. The bootcamp used a combination of team teaching, online sandbox repetition and experimentation, and project-based practice. The AWS materials provided by AWS Academy covered the details of the AWS infrastructure and were coupled with AWS Educate classroom sandboxes for practice. The two-week intensive practice and review certified 21 out of 31 high school students in the AWS Cloud Practitioner certification. This was the first time AWS Academy authorized high school students to take the certification exam and currently the largest cohort of high school students as AWS Cloud Practitioners.

This paper presents the details of the pilot implementation of the summer bootcamp part of the cloud literacy initiative. This pilot includes curriculum, pedagogy, and software tools. Surveys were administered to the students to collect their demographic information, assessments of the pedagogical approaches and interest in cloud computing. Also, pre- and post-exam scores were reported to analyze student performance outcomes. These results are presented to show the potential of such an outreach program to build capacity and broaden participation in the computing field through emerging technology.

Introduction

With the computing industry projected to grow much faster than other industries over the next 10 years, and as emerging technologies (EmTech) within computing-related fields such as cloud computing, AI/ML, cybersecurity, and data science grow and develop into mainstream technologies, many skilled jobs may go unfilled and business growth is threatened due to the shortage of trained professionals in these specializations [1]. For the past three consecutive years, cloud computing has been the most in-demand skill set companies are looking for when hiring

[2]. The demand of these skills creates opportunities for educational institutions to partner with industry leaders to increase effectiveness in preparing students for a fast-changing future, which may not require a four-year degree anymore [3], [4] or may require upskilling/reskilling cloud certificates.

With the rapid expansion of cloud technology, businesses are relying less on implementing costly physical data centers and more on cloud based “virtual” systems. These systems and their databases scale to process and store information rapidly and more efficiently than local physical systems. The National Institute of Standards and Technology (NIST) defines cloud computing as “a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction” [5]. Essentially, cloud computing leverages the Internet as a means to deliver computational and networking services that would otherwise be facilitated by local servers and/or personal computers. Cloud computing is an emerging area of computing/IT experiencing rapid growth in recent years. This development is due, in part, to the growing need to cost-effectively process, store, and secure large amounts of data. Because of its novelty, little has been done in higher education in terms of developing comprehensive curricula, educational resources, and training programs leading to industry certification [6], [7]. Furthermore, while the technology industry has experienced significant growth in recent years, this growth has not been matched by a workforce equipped with the appropriate specialized skill set. To meet this growth, the cloud literacy initiative was created to develop an educational pathway in this high-demand, high-wage area of computing/IT. Specifically, the partnership with Amazon Web Services (AWS), the industry leader in cloud computing solutions, aims to increase the number of certified cloud computing professionals from underrepresented groups to meet local and national workforce needs based on their two highest-paying AWS certifications, the AWS Cloud Practitioner and AWS Solutions Architect. These certifications have an average salary of \$140,456 (Table 1) and were deemed appropriate for entry-level students wanting to prepare for careers in cloud computing, and for experienced, working professionals who want to upskill, reskill, and prepare for cloud certification.

Table 1. Most Valuable Tech Certifications for 2020 [8]

Certifications	Annual Salary
1. Google Certified Professional Cloud Architect	\$175,761
2. AWS Certified Solutions Architect – Associate	\$149,446
3. CISM – Certified Information Security Manager	\$148,622
4. CRISC – Certified in Risk and Information Systems Control	\$146,480
5. PMP® – Project Management Professional	\$143,493
6. CISSP – Certified Information Systems Security Professional	\$141,452
7. CISA – Certified Information Systems Auditor	\$132,278
8. AWS Certified Cloud Practitioner	\$131,465
9. VCP6-DCV: VMware Certified Professional 6 - Data Center Virtualization	\$130,226
10. ITIL® Foundation	\$129,402
11. Microsoft Certified: Azure Fundamentals	\$126,653
12. Microsoft Certified: Azure Administrator Associate	\$125,993

Background

Global cloud services markets are expected to reach \$927.51 billion by 2027, and it is an absolute must for students to develop and acquire basic cloud technology skills to put them on par with the workforce of the future [9]. To support this need, the cloud literacy initiative focuses on three key activities: (1) development and implementation of a professional development program training faculty members to teach cloud computing courses utilizing problem-based learning methodology; (2) creation of an academic pathway in cloud computing; and (3) development of a K-16 pipeline by offering a cloud computing summer bootcamp for high school students. For the purpose of this paper, the focus is on the latter component of the initiative as it provides an opportunity to broaden participation in the cloud computing workforce by improving the pipeline from high school to college to employer.

We collaborate with AWS for the delivery of the curriculum and instructions. This academia-industry collaboration is composed of two separate entities: AWS Educate and AWS Academy. AWS Educate is Amazon's global initiative to accelerate cloud-learning and prepare learners for the cloud-enabled jobs of tomorrow. AWS Academy helps close the skills gap by providing higher education institutions with free, ready-to-teach cloud computing curriculum equipping students with skills needed to pursue industry-recognized certifications and careers in the cloud [10], [11]. In short, AWS Educate provides a flexible and informal environment focusing on learning at one's own pace with digital badges whereas AWS Academy provides a formal and structured curriculum to accredited instructors to teach toward industry certification. Miami Dade College worked with both entities taking advantage of their unique benefits.

To recruit for the bootcamp program, we co-hosted with Miami-Dade County Public Schools a Breakfast Tech event with High School principals at Miami Dade College. We presented our computer and technology programs with opportunities for students to participate in summer bootcamps and dual enrollment degree programs. At the end of the meeting, interested High School principals signed up for the cloud bootcamp. Their students filled out the online application for the bootcamp, which included current academic information, a letter of recommendation from their STEM teacher, and an essay. Students were selected based on the overall score of their application.

Motivation

Over the past decade, studies have shown that significant efforts have been undertaken to contribute to the computing education outreach in the K-12 schools, specifically on the teaching and learning of computing or computational thinking [12]. Computer literacy has been found to provide a significant economic, social and competitive edge to countries that embrace technological education in the K-12 classrooms. The production of professionals who can understand and sustain the technology needed to run all industries is critical. The ability to add value with the addition of creators and producers of technology rather than just creating consumers of technology is paramount to equality and success [13]. With this mindset, the initial work is to expand on the computing outreach topics with cloud computing. This is a new subject thus the initiative is to first build interest among high school students in the cloud computing field as an entry point into the computing/IT field.

Cloud Competency-Driven Bootcamp

We designed a two-week summer bootcamp, held at no cost for high school students with little or no experience in computer science to gain invaluable hands-on experience and potentially earn their first cloud workforce credential with AWS Cloud Practitioner. The bootcamp ran Monday through Friday from 8:30 a.m. to 4:30 p.m. with 10-minute break every hour and a one-hour lunch break at noon. Fridays were dedicated to fieldtrips and exam testing. Using the AWS cloud technology, the accredited and certified instructors delivered the ready-to-teach cloud foundations curriculum provided by AWS Academy. This curriculum covered the following cloud topics:

- Concepts: designing the AWS cloud, the economics of the cloud and basic cloud architectures.
- Security and Compliance: defining the shared responsibility model, what AWS security, compliance and access management concepts and capabilities.
- Technology: deploying and operating in a global infrastructure, identifying core services and support.
- Billing and Pricing: understanding the pricing models and account structures for AWS resources

Since AWS certifications are scenario-based questions, we use various pedagogical content and tools for students to master the new knowledge acquired and be prepared for the certification exam (Figure 1). Each pedagogical method chosen includes individual and group activities, lectures and readings, and access to video recorded lectures. Industry talks from leaders in the local field provided opportunities for real world non-academic discussions about the day-to-day activities in the field of cloud computing.



Figure 1. Pedagogy activities integrated to increase student success.

1) *Cloud Career Pathway*. Through the AWS Educate portal, students can explore career pathways with cloud skills relevant to in-demand jobs such as Data Scientist, Application Developer, and Machine Learning Scientists. This interactive visualization tool aids for career education.

2) Industry Education Curriculum. Accredited and certified faculty delivered the content using the lecture slide decks with notes from the AWS Academy portal and administer the online knowledge checks to assess comprehension. Students also have access to lecture videos and transcripts.

3) Problem-Based Labs. AWS Academy provides guided and problem-based lab materials through the Vocareum platform for engagement learning and critical thinking. Additionally, a “classroom” sandbox environment was created via AWS Educate portal to allow students to freely explore the AWS cloud technology with AWS free credits. Faculty also used this sandbox to create their own problem-based labs as supplemental materials.

4) Tech Talks. During the lunch breaks, we hosted an informal “Cloud On Demand Speaker Series” with cloud professionals from AWS, Centric Consulting, Accenture, Google, Microsoft to share their personal journey to the cloud and working in the cloud. Discussions were focused on the different tracks available to enter the cloud workforce and live demos were on their innovative cloud projects.

5) Fieldtrips. Business fieldtrips took place at local cloud-based companies (corporate and small-medium enterprise) to learn about the cloud business, cloud position roles, meet with their cloud team for technical presentations followed by Q/A session, and tour their facility.

6) Exam Prep. AWS Academy curriculum is not specifically gearing toward certification so A Cloud Guru certification prep and Whizlabs practice exams were used for content knowledge mastery through scenario-based questions testing.

Survey Methods

High School Bootcamp Participants

Students who attended the summer bootcamp were provided with daily surveys to complete at the end of each day of camp and focused on gathering feedback about what students learned each day, what may have been confusing, and their interest in the topics presented. At the end of the bootcamp, students completed a final survey that focused on knowledge gains, perceived value of the various kinds of activities that were part of the bootcamp, and overall satisfaction. In total, the Evaluation Team collected 297 survey responses, 265 from daily camp surveys, and 32 from the final survey.

Analysis

Once the surveys were closed, data was exported from the online software into MS Excel for analysis. Frequencies (i.e., the number of times a value occurs) were identified for closed-ended responses. Open-ended responses were analyzed using a general inductive thematic approach. This approach was selected because it is particularly useful in drawing clear links between research questions and data collection results. Once frequent themes and concepts were extracted from survey responses, the Evaluation Team reviewed the responses, adding contextual details and examples, and assigned counts based on the number of times those themes appear in the data. Once the analysis was completed, a summary report was developed for each survey.

Results

Thirty-one high school students participated in the cloud computing bootcamp, which was run concurrently with other bootcamps. The cloud cohort was composed of students from

underrepresented groups with 31% Latinx, 28% Black or African American, 35% mixed-race Latinx/Black or African American, and 6% prefer not to answer. An overall positive finding with a significant interest in entering the computing-related fields with cloud computing, and the potential to broaden participation of underrepresented groups in the K-12 schools through stackable industry certifications and problem-based learning.

Overall Student Feedback

In this section, we summarized pertinent feedback in regard to interest, knowledge acquisition, and pedagogy activities.

Prior to the camp, most students (94%) showed at least a slightly interest and curiosity toward cloud computing education/careers (Figure 2).

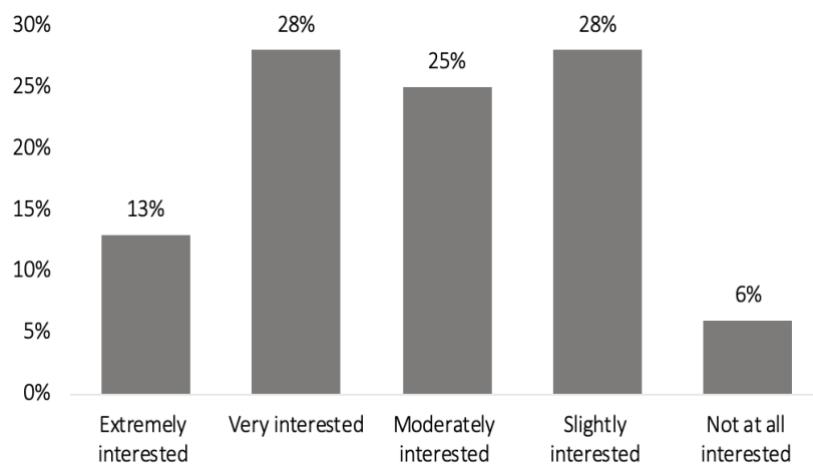


Figure 2. Interest in Exploring Cloud computing Education/Careers (Presurvey)

Upon completion of the bootcamp, interest appeared to increase as all students (100%) noted they were moderately to extremely interested in the cloud computing education/careers (Figure 3).

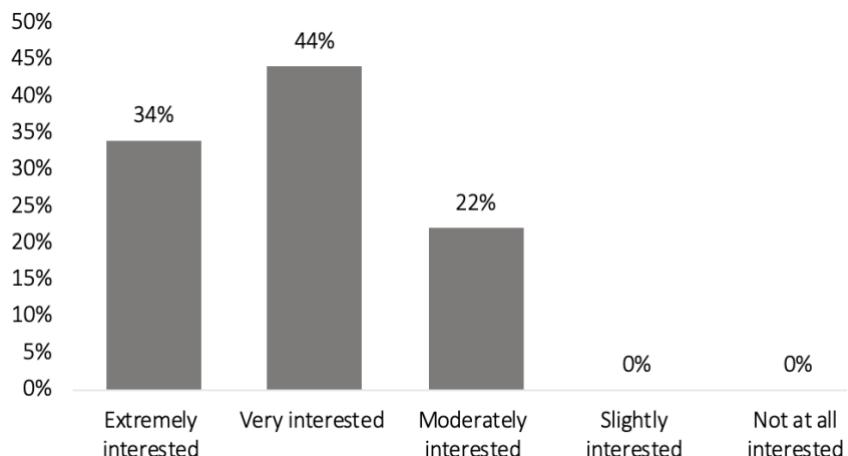


Figure 3. Interest in Exploring Cloud Computing Education/Careers (Postsurvey)

With this, most students (85%) indicated that they would likely take cloud computing courses at Miami Dade College following the bootcamp (Figure 4).

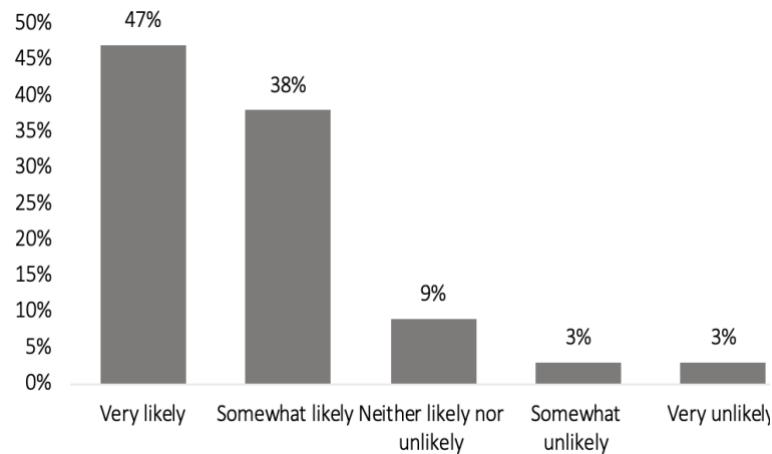


Figure 4. Interest in Pursuing Cloud Interest Through a Formal Academic Pathway

Comments addressed themes such as how interesting the topic areas were, interest in pursuing a career in the cloud, and excitement with the increase in knowledge around cloud computing. Despite few students indicating no interest in further pursuing cloud computing opportunities, all students (100%) agreed that they experienced a knowledge increase after completing the camp and nearly all students (84%) indicated a significant increase in knowledge (Figure 5).

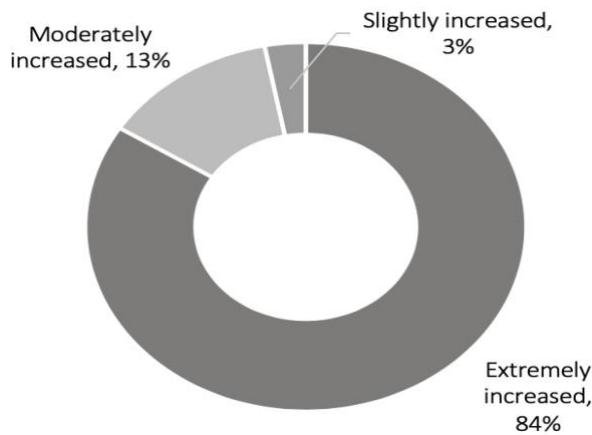


Figure 5. Impact on Knowledge Increase in EmTech/Cloud Computing

When asked how valuable each pedagogy activity during the camp was for them, students generally noted that all activities were very valuable. Students tended to rate the following more favorably than the other activities, with “very valuable” ratings at 75% or higher:

- Classroom lectures
- Problem-based labs
- Exam preparation with A Cloud Guru
- Cloud On Demand Luncheon Speaker Series
- Review sessions with instructors and professionals

Students were asked to identify their favorite cloud topics they learned during camp and the most notable responses concerned about the security for the Cloud and overall cyber security; the application of the different AWS services; and the presentation demos on AWS Lambda with Alexa, Amazon Translate, and Amazon Rekognition.

When asked what students would change about the camp, the most frequent themes that surfaced were around the need for moving the review to the end of the day so it is not rushed, more hands-on time, and making the camp longer. Otherwise, most students responded with no improvements needed. With this, nearly all students would recommend the camp to another high school student (90.63%).

Competency-Based Outcomes

In this section, we summarized the findings to student learning as it relates to the cloud topics. For comprehension assessment, we included two practice tests during the second week of the bootcamp. The practice tests are based on the industry certification AWS Cloud Practitioner, which is to demonstrate knowledge, skills, and abilities in the overall understanding of cloud computing using the AWS platform, regardless of the specific technical roles.

The first test was administered at the beginning of the week, immediately after the completion of the cloud foundations curriculum. The second test was administered at the end of the week, the day before the industry certification exam. The tests included scenario-based questions randomly selected from a large pool of questions while still ensuring the domain breakdown satisfied the exam blueprint as follows: cloud concepts (26%), security and compliance (25%), technology (33%), billing and pricing (16%). The test passing score is 70%.

Results from the first test showed that more than three-fourths of the cohort had a solid grasp of the first two cloud topics covered in the first week, whereas the last two topics still needed more explanation and study (Table 2). These initial results guided the three-day review session conducted by the instructors and professionals.

Table 2. First Test Scores Breakdown

	Concepts	Security	Tech	Billing	Final Score
Less than 70%	23%	16%	52%	81%	32%
70% - 79%	0%	13%	16%	0%	6%
80% - 89%	42%	23%	29%	0%	45%
90% - 100%	35%	48%	3%	19%	16%

Results from the second test showed significant improvement in the comprehension across all four cloud topics with 93% of the cohort passing the test (Table 3).

Table 3. Second Test Scores Breakdown

	Concepts	Security	Tech	Billing	Final Score
Less than 70%	10%	0%	6%	26%	3%
70% - 79%	0%	3%	16%	0%	0%
80% - 89%	19%	23%	26%	0%	29%
90% - 100%	71%	74%	52%	74%	68%

The proctored industry certification exam for AWS Cloud Practitioner was administered through on-campus testing center on the last day of the bootcamp. The certification passing rate was 67.7% (21 out of 31 students) for the two-week bootcamp participants (Figure 6). A few students experienced testing anxiety and some students may have been too sure of themselves; thus, these factors may partially explain this outcome.

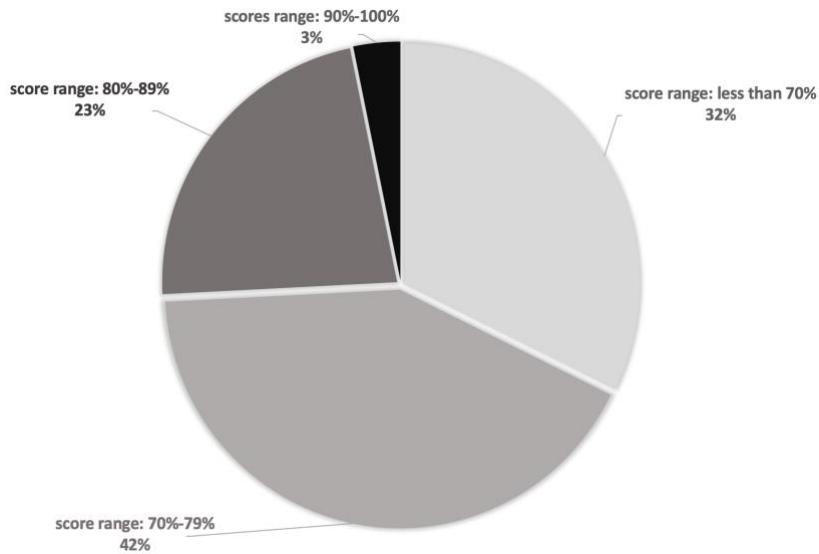


Figure 6. Certification Exam Results

Conclusion and Future Work

AWS Academy course materials are geared toward college students and as such an exemption from AWS Academy to teach the AWS course material to high school students was requested and the 2019 bootcamp was the first pilot for high school students. The national average for professionals successfully passing the AWS Cloud Practitioner exam was in the range of 60-70% in 2019 and the cohort performed at a 67.7% success rate on their first attempt. Based on AWS historical data this is very impressive. The most important fact is, they were the first high school students in the country to go through the AWS Academy curriculum. Given the compressed

timeframe for the bootcamp, the team-teaching approach strengthened the teaching and learning offered. Students were able to engage with multiple college faculty having a variety of expertise (application development, cybersecurity, networking, and data science).

Furthermore, 30 out of 31 students continued as dual enrollees into the college credit certificate in cloud computing the following academic year 2019-2020. Students who earned their AWS Cloud Practitioner certification received college credit toward the cloud essentials course. The remaining students enrolled in the cloud essentials course with college students to cover the materials at a slower pace. The cloud computing certificate includes courses in networking, Linux, databases, cloud infrastructure architecture and a capstone course taught in partnership with local cloud-based companies working on agile, problem-based cloud solutions using real-world problem solving (Figure 7).

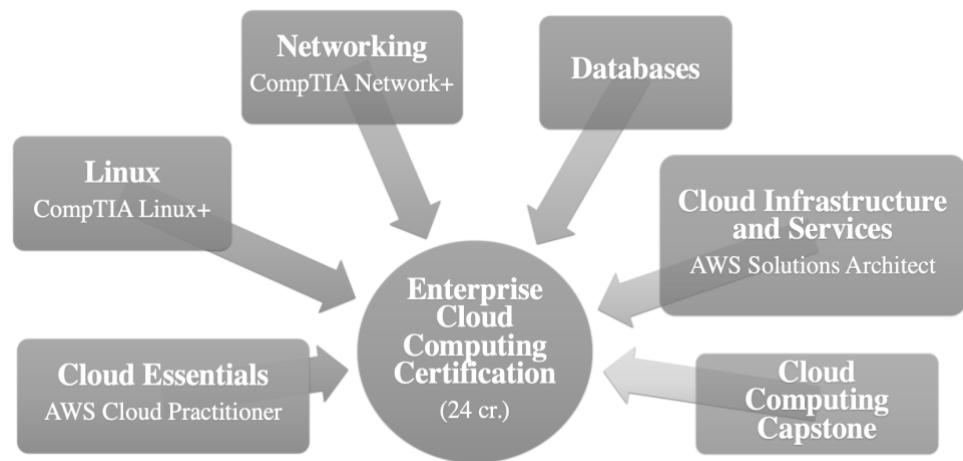


Figure 7. College Credit Certificate in Cloud Computing

The majority of the students enroll in this certificate in conjunction with their associate or bachelor's program in the computing/IT field. Although the COVID-19 pandemic interrupted for some of them their learning, so far 10 out of 15 dual enrollees registered in cloud infrastructure course earned their AWS Solutions Architect – Associate certification and 15 enrollees completed their enterprise cloud capstone projects followed by a summer internship. This initiative has produced some of the first, and youngest, certified solutions architects in the country.

Based on the pilot success, AWS Academy has extended an invitation to a handful of high school students to join AWS Academy starting in January 2020. With this new direct connection between AWS Academy and K-12 schools, the plan is to shift efforts in building increased quantity of high school teachers to provide relevant and up-to-date education in cloud computing through a dual enrollment college credit program hosted at their respective schools. Furthermore, due to the urgency in hiring in these cloud specializations, the top cloud providers AWS, Google, and Microsoft recently opened access to their education materials and provided self-paced online informal learning in EmTech at low cost and over a short period of time (six-month program) [14]. Miami Dade College has strengthened their academic-industry partnerships to work more closely with industry partners in order to meet their workforce expectations and develop curricula that align with the workforce of tomorrow based on cloud computing job roles.

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