

Transforming Education: Upskilling for a Cloudy Tomorrow

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ABSTRACT

Cloud computing deployment and demand has increased year over year during the prior decade and has only accelerated during the COVID-19 pandemic. The rapid increase in cloud technology has also increased the need for higher education institutions to train students and re-skill or up-skill working professionals. This paper discusses the application of high impact training methodologies and their impact on student learning.

CCS CONCEPTS

• Social and professional topics → Professional topics → Computing education

KEYWORDS

academic-industry partnership; amazon web services; cloud computing literacy; college credit certificate; high-impact pedagogical practices; project-based learning; reskilling; upskilling.

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1 Introduction

There is a significant shortage of experienced cloud professionals. In fact, 63% of surveyed IT decision makers expect this gap to widen in the next two years, and many industries are curtailing their plans for migration to the cloud or business expansion as a result [1, 2]. A recent global study, LogicMonitor's Cloud 2025, indicated cloud deployment is accelerating in response to the current global pandemic with 74% of the respondents indicating 95% of workloads will be deployed to the cloud [3].

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Many industries are focusing on replacing on-premise computing systems with cloud-based, highly available and highly scalable computing systems with the goal of only 22% of the traditional workload being on premise by 2025 [4]. Traditional information technology (IT) and computer science programs need to prepare current and future students to enter a workforce eager for skilled individuals who are ready to work in a variety of roles with cloud technology. The existing cloud talent pool cannot meet this demand, and that demand is everywhere, in every industry. In fact, predictions indicate that 30% of high-demand jobs in emerging technologies will continue to remain unfilled through 2022. Meanwhile, the cloud divide could cost businesses millions in revenue, estimated to \$258 million, because of the slow pace of cloud adoption due to lack of trained technicians [5].

Cloud technology is a transformative technology for corporations and education. COVID-19 forced a radical transformation from traditional work and education to new form of working and learning from home. As Microsoft CEO Satya Nadella said "We've seen two years of digital transformation in two months" [6]. The result of the rapid expansion of cloud technologies is the rapid increased demand for skilled professionals in those technologies. This demand requires both the up-skilling and re-skilling of students and professionals. These cloud professionals will require both adaptability to new environments for one or more cloud providers, and the ability to learn new cloud technologies as they come into service. The skills needed can be thought of as "near future skills", those under current adoption, such as cloud computing and "future skills", or those on the future path for the business technology, such as quantum computing and artificial intelligence/machine learning (AI/ML). Each of these current and future skills will require students to understand the current role(s) they wish to pursue, and the need to create an educational plan for their desired future role(s). They must plan to remain relevant in the technology for their future employers, requiring them to continuously plan for up-skilling and re-skilling educational opportunities [7].

For education to provide current and returning students competent hands-on business cloud literacy knowledge, there needs to be high impact pedagogical activities to mimic real world experience. "As many fields of study have discovered learning by doing through internships can provide highly valuable experiences for students, not just for career exploration and future job placement, but for enhancing academic achievement, personal growth, and other positive educational outcomes" [8]. In emerging technology fields, opportunities for internships can be difficult to find. A solution is a

collaborative project-based learning (PBL) course, combining local business resources and classroom technologies. PBL is “an exploratory learning mode developed around projects, projects are complex tasks, in order to complete the goals of the projects, learners must [...] participate in design, solve problems, and make decisions” [9]. The process of constructing actual real-world projects and reorganizing the teaching content helps students extend limited classroom instruction into the domain of practical business application [10]. To create successful learning environments, the classroom must be redesigned into a student-centered learning environment particularly using the learning platforms, documentation, and teamwork to conduct co-learning activities [10].

To accomplish this, the major cloud providers, Amazon Web Services (AWS), Microsoft Azure, Google Cloud, and IBM Cloud provide access to their commercial cloud systems or to a restricted simulated subset of their systems. This allows for PBL systems to teach and train students on the same platforms they will use in the business environment. The use of the cloud platforms providing near commercially identical systems and capabilities their commercial customers utilize, students engaged in PBL emerge with solid readily useable capabilities and understanding or these systems, enhancing their employability. In the next section, we highlight the student population, curriculum, and pedagogical activities of our new cloud computing program at the College.

2 Enterprise Cloud Computing Program

Miami Dade College is the largest and most diverse public college in the nation and the largest Hispanic-Serving Institution (HSI), conferring more associate degrees to Hispanic students than any other college. The College also enrolls more Hispanic undergraduates (59,703) than any other U.S. college or university and has the third largest Black non-Hispanic undergraduate enrollment reflecting the racial and ethnic diversity of the 2.4 million residents of its service area. Enhancing the employability and job prospects of the residents is core to the College mission and enables community members to meet and exceed their dreams. As a college that focuses on underserved populations, this program is designed to enhance the economic opportunities for our current students and professionals.

The need to upskill is significant, as new jobs, skills and job opportunities tend to appear before traditional learning pathways adapt. Older workers must prepare to constantly learn these new skills and apply their existing skills in novel ways to a changing labor market. During 2015, there were nearly 5,000 job postings that mentioned cloud computing [11]. According to the Department of Labor for our region there were 2,453 unique job postings for cloud and related technology jobs in May 2020. The number of postings had a ratio of six postings per job, this larger ratio of postings to unique jobs indicated a strong need for these jobs and a harder time filling them. Moreover, research by LinkedIn highlights that many commonplace top job titles used by employers today (e.g., data scientist, cloud service specialist, digital marketing specialist) did not even exist in 2008 [12]. For the past five

consecutive years, cloud computing has ranked in the top three in-demand skills by both LinkedIn [13] and Global Knowledge [14]. With proper training and credentials, current students, graduates, and other professionals can learn the cloud skills needed and applying them to their employer’s needs.

The Enterprise Cloud Computing, a 24-credit certificate-based curriculum, was designed as stackable for the successful completion of the first college credit certificate in cloud computing in our State. The curriculum was designed with faculty in conjunction with AWS Academy and AWS Educate professionals to ensure coverage of cloud basics, the AWS Cloud Practitioner and the AWS Solutions Architect certifications. AWS partners assist in the design of AWS curriculum and coverage based on both AWS technical needs and partners hiring requirements, allowing for a robust platform and partner supported program. Through the AWS partners network, this collaborative curriculum framework is used as a reference model by other U.S. higher education institutions for the design and launch of their own cloud computing programs. Additionally, the collaboration between MDC and AWS in the development and implementation of the cloud programs as a pathway into the workforce has been presented at national and state conferences to engage more employers to hire college-level cloud students and encourage high schools, colleges, and universities to develop cloud programs.

2.1 Curriculum

Our cloud literacy journey with AWS started three years ago with faculty professional development and now our students are being placed in entry-level cloud focus or cloud related positions (Figure 1).

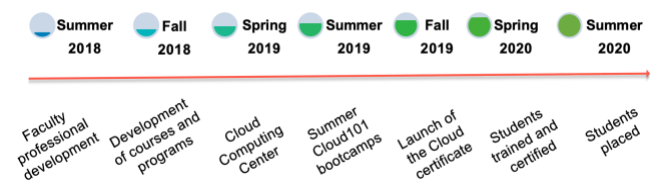


Figure 1: Cloud Literacy Journey

The newly developed CCC in Enterprise Cloud Computing and its related tracks in other degrees requires three new cloud focus courses:

1. Cloud Essentials (required) introduces AWS cloud basics and foundational cloud terminology. This course prepares students for AWS Cloud Practitioner certification.
2. Cloud Infrastructure (required) introduces AWS essential services and their applications in architecting complex business solutions. This course prepares students for AWS Solutions Architect certification.
3. Cloud Capstone (required) pairs students with industry project mentors building real-world cloud solutions (remotely). This course prepares students for real-world projects using an agile approach.

In addition, “cloudification” (cloud related) of four existing courses took place as follows:

1. Databases (required) introduces deployment of various relational (Amazon Relational Database Service) and non-relational (Amazon DynamoDB) databases. This course prepares students for fundamental database design and implementation need to store and process data.
2. Linux (required) provides access to multiple Linux virtual machines and labs, giving opportunities for risk free exploration of the manipulation, installation, and utilization of Linux tools via AWS Cloud9 IDE. This course prepares students for CompTIA Linux+ certification.
3. Python (optional) pairs with the core functionality of many pivotal cloud technologies and is highly recommended due to its modern design and inherent usability in working with data intensive projects, streaming analytics, and stream processing. This course prepares students to build applications on top of Amazon S3, Amazon EC2, Amazon DynamoDB, and more via AWS Cloud9 IDE.
4. Networking (required) provides fundamental understanding on how networks, IP addressing, and security all work to connect to compute resources. This course prepares students for the CompTIA Network+ certification.

These existing courses are already part of their computing/IT degree at the associate and bachelor level (e.g., cybersecurity, data analytics, information systems technology). With this in mind, the college credit certificate in Enterprise Cloud Computing (24 credits) is an 8 to 11-month program that students can enrolled concurrently with their current program of study [15]. In the next section, we present the core pedagogy of the program.

2.2 Pedagogical Activities

PBL has become the gold standard for encompassing realistic training in technology environments. Cloud-based education has a large scope across many dynamic areas of cloud computing from programming, networking, databases, security, infrastructure, and AI/ML. Empowering students with incorporating practical PBL and experiential learning activities, in addition to industry expertise and experience, allows diverse and real-world training possibilities for them. Cloud providers utilize multiple case studies in their instructional materials providing insights into how the cloud platforms are being used and implemented [16]. Table 1 summarizes the various pedagogical activities part of the Enterprise Cloud Computing program, in particular the ones that pertinent to high impact educational practices.

Table 1. High Impact Educational Practice Activities

Activities	Purpose	Activities
Project-based Learning	Development of critical thinking skills, problem-solving abilities, and	Provide guided and problem-based lab materials through a sandbox environment.

	communication skills by working on “real-world” problems	Exploration of the AWS cloud technology is at no cost. Faculty use this sandbox to create their own problem-based labs as supplemental materials.
Experiential Learning	AWSome Day labs, run by AWS and IT business professionals, provided students with professional engagement using creative projects	Development and usage of IoT 1-Click, AWS DeepRacer, AWS Chatbot, and AWS Rekognition in practical real-world activities.
Collaboration and Teamwork	Capstone projects derived from business partnerships using real-world projects and teaching teamwork using an agile approach (scrum).	Partnership with local cloud-based companies working on partner business challenges with professional guidance.
Cloud Career Pathway	Access to the AWS job board, career information, and skills relevant to in-demand jobs.	Explore career pathways using an interactive visualization tool aids for career education in Data Scientist, Cybersecurity, Application Developer, and Machine Learning Scientists.
Internships	Practical application of skills and experience in a work environment	Internships hosted by Florida Power & Light (FPL), AWS, Belle Fleur, Presidio, Nub8, Keyrus
Business Fieldtrips	Develop greater understanding of business operations and opportunities in cloud related companies such as Kaseya, Amazon AWS Warehouse and CareCloud.	Fieldtrips to local cloud-based companies (corporate and small-medium enterprise) to learn about the cloud business, cloud position roles, and meet with their cloud team for technical presentations followed by Q/A session, and tour their facility.
Guest Speaker Series	Industry talks from leaders in the local field provided opportunities for real world non-academic discussions in the field of cloud computing.	Discussions about daily activities with Belle Fleur, Amazon AWS, Google, Accenture Women In Cloud, and Microsoft cloud professionals.

3 Methodology

After training faculty designing the course pedagogy and curriculum, initial training was delivered to an initial group of high school students and the first cohort of college students. The evaluation is focused on helping the college understand how the development and implementation of the Enterprise Cloud Computing program impacted these students. The Evaluation Team facilitated two focus groups with cloud students who participated in the program, gathering feedback on their experiences in the program, their perceptions of the program as it prepared them for employment, and the next steps that they hoped to pursue after completing the program.

3.1 Data Collection

Two focus groups were conducted, one for male students and one for female students. During the Fall 2020 term, the grant coordinator reached out to the 35 program graduates to participate in focus groups. The groups were assigned by gender with seven male students and six female students participating. The focus groups were utilized to gain feedback from students in the program on their experiences, their perceptions of the ways in which the program prepared them for employment, and the next steps that they hoped to take after completing the program. The Evaluation Team developed a facilitation guide outlining questions based on feedback from the program leadership. During focus groups, verbatim notes were taken, and the sessions were recorded, with participants' permission.

3.2 Analysis

Data collected from the focus groups and written submissions were analyzed using a general inductive thematic approach. This approach was selected because it is particularly useful in drawing links between research questions and data collection results. Emerging themes were developed through a review of the notes taken during the focus groups according to the coding frame. Following this initial development of these themes, the Evaluation Team reviewed the results, adding contextual details and examples. To solidify and strengthen the credibility of the findings, the Evaluation Team relied on triangulation and collaborative inquiry. Responses from all students were analyzed together, as findings were reported in the aggregate in this summary report.

3.3 Limitations

3.2.1 Partial and Biased Findings. Qualitative research methods offer good insights, but are, by nature, partial and biased. To attempt to address this limitation, the Evaluation Team took advantage of an opportunity embedded in mixed-methods evaluation, the triangulation of data [17, 18]. Triangulating results from multiple sources, such as comparing findings among multiple stakeholder interviews and with documents reviewed, creates more credible evaluation results, and is considered critical to the validity and reliability of findings [19]. Findings that have been corroborated through triangulation tend to be sufficiently robust and credible [20].

3.2.2 Selection Bias in Student Data. Selection bias is inherent in the sampling methods deployed for student focus groups. To address the threat of non-response, the Evaluation Team relied on the program leadership to recruit students for focus groups. This approach introduces the potential for research participants to be selected based on their willingness to speak favorably about the program. Neutral and critical feedback from students, however, supports the notion that these research participants were chosen primarily for their willingness to participate rather than the likelihood that they would cast the program in a favorable light.

4 Results

The findings from these two focus groups are highlighted below based on overall program experience and post-completion plans.

4.1 Feedback on the Cloud Program

4.1.1 Students saw opportunities to position themselves for careers in cloud computing when enrolling in the program. "I thought this was the most organized program at the college. Not just a curriculum, but it is a bridge to industry," explained one student. Another noted that the opportunities for cloud computing are present in most IT companies, so training in this field could open many doors for them. "I was able to develop programming skills," noted one student, "with cloud computing, you can quickly deploy and build in a lot of fields." Other students appreciate the opportunity to earn credentials, "this program is amazing, it gives you a chance to reach for something you aspire to do," and "[it] prepares you with the chance to earn certifications."

4.1.2 Industry certifications are perceived to be of some value when seeking employment, but experience is crucial. Students reported that the industry recognized credentials that they earned are valuable for entry-level work, as they are introductory credentials. "They make your resume look good," explained one student. Another reported, "the industry certificates earned throughout the program are valuable badges to give credentials to the knowledge you've obtained." However, students noted that "they are only as impressive as your projects are." Another echoed "if you have experience with those credentials, it is better." Students reported that the credentials are "a proof-point of the fundamental skills, but at the end of the day, nothing beats experience. It is up to you to prove you can do [the work]."

4.1.3 Students who were new to the computing field expressed that they needed more time to learn the topics covered in class. Some students noted that courses cover a lot of content, and that they needed to invest significant time outside of class to review the content. As one noted, "learning to code is the hardest part. It's as if you're learning a completely new language. Understanding how to read and write programming languages becomes more complex as different logics and functions come into play." Students who were career changers reported that "if you have been in the field [of computing], it is much easier for you to understand the concepts. It's a whole new world for me, it was difficult."

4.1.4 More hands-on practice with the skills and concepts learned in class was desired by students. "One of the things I liked the most

about the program was the hands-on labs, the theoretical is only helpful to a certain extent, after that, it's about experience and practical knowledge," explained one student, "we need more time to practice." Another echoed, "you need more opportunity to use the practical applications of [what we learned], the challenge wasn't learning the concepts, but really being able to apply them." Additionally, a student noted that "I feel like I need more hands-on practice, sometimes I review the AWS videos to refresh my knowledge."

4.1.5 Many students who completed their capstone course felt there was room for improvement. Some students noted that the time commitment needed was difficult for students who worked full- or part-time in addition to being students. They noted that felt that they were still learning new skills and concepts, and then the capstone "left them out on their own."

4.1.6 Study and prep tools were reported to be beneficial for cloud students, and only a few students had used the AWS Educate Job Board. "[The] College has provided me with an abundance of resources to utilize," explained one student. Students reported that the sample test questions were helpful, as the questions were more similar to the exams than they were in some of the other tools. Students who utilized the whitepapers that were available explained that they appreciated the opportunity to "understand the why" behind the concepts. Those who utilized the AWS Educate Job Board reported that they appreciated the AWS Career Support when creating their profiles, but that they had not necessarily pursued opportunities posed yet.

4.2 Feedback on Post-Program Plans

4.2.1 Completion of the certificate program could prepare students for entry-level jobs in cloud computing. Students perceived that their preparation through the program would position them for entry-level work, as they believe that "you will have to build on what you learned in class before they [companies] will let you do it on your own." Students who had internships expressed that their internships also prepared them well for careers, as one student explained, "[my internship was] very valuable for the program, so I could put everything I learned to use." Echoing sentiments about the need for more hands-on experience, one student reported, "I think after this, I will be qualified for entry level internship. To get a job where I can make enough money to live my life, I will need more projects and experience under my belt."

4.2.2 Those without work experience reported angst about joining the workforce. Students reported that they often found that even entry-level jobs required some amount of previous experience, "the lack of experience is a challenge, because unless you find someone that will give you a chance to get that experience, it will be hard to find a job," articulated one student. Another noted that without understanding the business components of the industry, they felt underprepared, "cloud computing is supposed to save the business money. Depending on what the company wants, it can be hard to define and predict the costs of a solution. I don't want to damage that, you need a lot of experience," explained another student. Another questioned, "if you don't have a business background, where are you going to get that experience?" These students also

noted that they wished that the College provided more interview preparation to ease their concerns and noted that this could include more projects that could be included in a portfolio of work. Another noted that preparation for coding interviews would help them to be more prepared when seeking employment.

4.2.3 Program completers hoped to pursue additional training and careers in cloud computing. Many students noted that they are interested in pursuing education in cybersecurity, as they felt that cybersecurity and cloud computing were closely related, and that understanding both would position them well for careers. Others reported that they were pursuing internships to build their hands-on experience and hoped to earn more credentials in related skills. "The additional training will help bring an arsenal of tools at my disposal," reported one student. Another student explained, "I plan to seek a job while finishing my degree. Currently, I am working on new skills that may bring more value to offer companies while also applying for new internships and some junior level job positions."

4.2.4 Program helped students solidify their career goals and aspirations. When asked about their career goals and the ways in which the cloud computing program may have impacted their goals, one student noted, "The program inspired me. It was beautiful in that way. It showed me so many possibilities of things that exist. It's not just AWS, you can take analytics and coding and put it together in a seamless way; those pieces are the glue." Students expressed that their dream jobs were to work in cloud computing for large companies like Google, Amazon, AWS, SpaceX and Microsoft. They reported that they are interested in roles such as systems administrator, DevOps engineer, cloud analytics, cloud security engineer, and enterprise infrastructure. Students reported that to achieve these goals, the certificate program was a strong first step. "I would say the first thing is to learn the skills," noted one student. Another explained, "I am happy, I think I am taking the right steps.... the cloud certificate really make you have that itch [to keep progressing]."

5 Conclusion and Future Work

From September 2019 to March 2021, our cloud literacy program has certified a total of 74 AWS Cloud practitioners, of which 21 were high school students, and 39 Solutions Architects including 10 high school students (Figure 2).



Figure 2: Student Training and Certification Outcomes

Students in the program who certified in AWS Cloud Practitioner and/or AWS Solutions Architect received internship and full-time job offers from Belle Fleur, Amazon AWS, Intel, Telefonía, Disney, Florida Power & Light, Generation USA, Presidio, and more.

During the past year, COVID-19 restrictions, lock downs and the explosive growth for the need of online connections caused an exponential growth in cloud-based systems and technologies. The nature of the materials and systems used for the cloud related courses moving fully online were a quick pivot for us. This enabled the continued education of students in an increasingly high demand field.

Future work is to revise and enhance cloud offerings with the development of advanced multi-cloud courses and degrees in DevOps and Data Analytics. To achieve this, a Business Industry Leadership Team (BILT) composed of local company experts in cloud is coordinating the validation of the Knowledge, Skills and Abilities (KSAs) needed for individuals in the program [21]. These validated KSAs will be compared to existing and future course competencies and degree frameworks to ensure correct coverage and integrate student feedback. Not only has industry expressed the need for advanced trained graduates and professionals, but it is also expanding cloud systems from single source providers into hybrid or multi cloud systems, with 90% of global enterprises developing hybrid cloud solutions [22, 23]. Our response, in keeping up with industry focus, is to expand our current cloud partnership with Amazon AWS partners network to include Microsoft Azure, Google Cloud, and IBM Cloud representatives from our region in our effort to develop a collaborative curriculum framework to align with our bachelor's degrees in Information Systems Technology, Cybersecurity, and Data Analytics. The demand of these skills creates opportunities for higher education 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 [22, 24] or may require upskilling/reskilling cloud certificates [25]

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