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Building a Student-to-Workforce Pipeline for 21st Century Cloud Industry Careers

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Building a Student-to-Workforce Pipeline for 21st Century Cloud Industry Careers

Abstract

Cloud migration has accelerated and companies around the world are investing their technological future with the cloud. Given the growing industry demand for cloud related skills, Miami Dade College partnered with the industry leader in cloud computing solutions Amazon Web Services (AWS). In conjunction with AWS, we developed a new cloud-based learning curriculum designed to provide an academic gateway for the next generation of computing technicians to meet local and national workforce demands. The recruitment population focused on predominantly minoritized and low-income populations. This certificate-based curriculum is designed as stackable for both the successful completion of a College Credit Certificate and/or an Associate of Science in Networking Technology with a concentration in Enterprise Cloud Computing.

The curriculum was developed in alignment with industry needs and utilizes high impact educational practices. The cloud computing programs prepare students to potentially earn an academic credential and globally recognized industry certifications at the entry (college credit certificate) and associate levels. Ensuring students are offered the highest standard of training, faculty members completed professional development in cloud computing, earning industry-recognized credentials to become AWS-accredited instructors. The current cohort of faculty certified to teach in the AWS Academy is the largest group of certified instructors in the academic arena.

The inclusion of industry standard certifications from major cloud providers allows for consistency of program evaluation and instructors assessment of student work and course comprehension. The net effect of these certifications is not only earned degrees, but employer ability to validate prospective employee skill and knowledge outside of an academic environment.

This paper presents the approach followed in developing in-depth, project-based learning opportunities using cutting-edge technology for the new academic pathway in cloud literacy and the program outcomes. A discussion on the best practices and lessons learned while implementing the first year of the program is included.

Introduction

There is a significant shortage of experienced cloud professionals with 63% of U.S. organizations expecting this gap to widen in the next two years [1]. Cloud migration has accelerated, and companies around the world are investing in their future with the cloud. Many industries are currently focused on replacing on-premise computing systems with cloud-based, highly available and highly scalable computing systems. The gap in cloud skills has doubled in the last three years and a recent study reveals that 87% of enterprises will accelerate their cloud migration in the post-COVID-19 world [2]. Traditional IT and computer science programs need to prepare graduates of their programs to enter a workforce eager for skilled individuals ready to work in a variety of

roles with cloud and hybrid systems. According to the U.S. Bureau of Labor Statistics, the computing job industry is projected to grow much faster than other industries over the next 10 years, and as emerging technologies within computing-related fields such as cloud computing develop further, the gap between available computing jobs and qualified applicants is only expected to grow [3]. 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 [4]. Meanwhile, the cloud divide could cost businesses millions in revenue due to the slow pace of cloud adoption.

Miami Dade College (MDC) is the largest U.S. Hispanic-Serving Institution (HSI), conferring more associate degrees to Hispanic students than any other college. MDC 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. With MDC being the largest and most diverse public college in the nation, underrepresented students are the targeted population for this initiative. In response to cloud talent shortage, MDC launched a cloud literacy initiative to invest in cloud professional training with the industry leader in cloud computing solutions, Amazon Web Services (AWS). The cloud initiative included three components described in Figure 1 as follows:

- Provide faculty professional development in cloud computing to teach cloud-related courses
- Create academy pathways in cloud computing
- Recruit college students and high school students

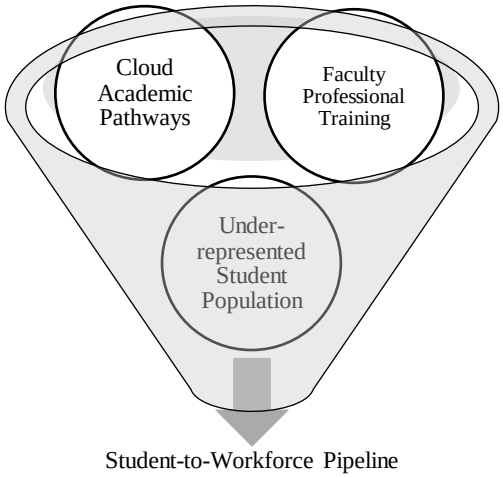

Figure 1. Academia-Industry Cloud Literacy Initiative

Academia-Industry collaboration in research has been a long-standing tradition, allowing access to materials, laboratories, data and expertise [5], [6]. Coghlan and Coughlan identified three particular insights into collaborative research, which are: 1) linking theory, practice, and collaboration; 2) capturing differences while sustaining collaboration; and 3) managing quality [7]. These same insights apply to the use of cloud-based technology in the classroom, where focusing on business software literacy and skills in as close to real-world applications is critical [8]. AWS provides two separate groups within Amazon that assist in sharing resources and expertise; the AWS Academy and the AWS Educate. To bridge the gap between small scale and theoretical cloud skills to deployment in business scale systems, AWS Academy provides free

cloud resources, professional training and industry standard curriculum to institutions and educators. The standardized curriculum focuses on the key AWS certifications needed for industry jobs [9]. AWS Educate provides global access to cloud resources for college students, higher education faculty and colleges for degree programs and also provides resources to employers and students for job postings. Their resources are not focused on certification, but on sharing access to cloud resources [10]. Approached by AWS to deliver certified-cloud courses and use AWS cloud environments in education, MDC determined faculty first needed training and certification on their platforms

Faculty Professional Development

To facilitate the use of the AWS platforms, AWS Academy provided hybrid faculty professional development (FPD) training based on online training and train-the-trainer model. This model focuses on initially training faculty who, in turn, train others in the material they learned. Train-the-trainer has been shown to be effective and efficient in education and multiple modes of training across industries [11], [12]. The FPD was divided into three steps as highlighted in Figure 2 below.

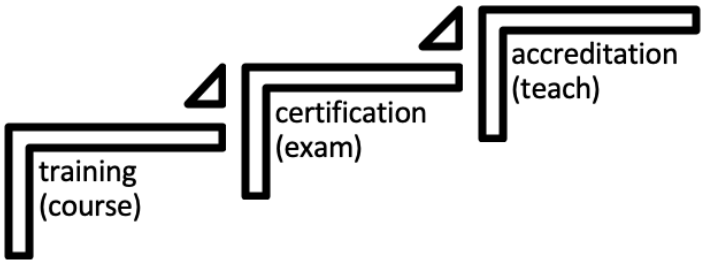

Figure 2. Three-step training validation process.

In step one, faculty participated in a three-day in-person immersion cloud training led by AWS technical experts, accompanied by a self-paced online training. The curriculum for the technical training included:

- Live and/or digital lecture modules covering technical concepts
- Hands-on guided labs in the AWS Console to practice skills in a sandbox environment
- Knowledge checks to assess comprehension for each module
- Scenario-based projects to develop and implement AWS solutions

The AWS Academy pedagogical approach is rooted in experiential learning, where learners are introduced to cloud basics then proceed to practical, hands-on learning or "the process whereby knowledge is created through the transformation of experience" [13].

Step two, faculty sit for the AWS Cloud Practitioner and/or the AWS Solutions Architect certification exam. Passing the exam is required to proceed.

The third step is to be accredited to teach in AWS Academy. To achieve accreditation, faculty perform a two-hour teach-back with an AWS technical expert to ensure faculty consistently deliver AWS accredited materials.

Once faculty become accredited, full access to the ready-to-teach materials and lab resources are provided. AWS Academy aligns and routinely updates their cutting-edge curriculum based on industry interest and demand. Recent examples of material updates include database, data analytics, networking, security, machine learning, and internet of things. Once faculty are trained and certified, the next target of MDC was to codify these certifications into academic pathways through the design and creation of cloud-based courses to reflect the material in these certifications.

Cloud Competency-Driven Academic Pathways

The certified instructors drove the conversations on how to best translate this certification process into individual courses and pathways. Early in the certification process for AWS Solutions Architect, AWS released a foundational certification named AWS Cloud Practitioner. This allowed for the addition of a cloud foundations course based on it and an advanced course based on the Solutions Architect. The ordering of these courses builds on student success and learning from the ground up. The new cloud pathways are designed to align industry certifications with additional core classes needed to prepare students for entry level cloud jobs. These courses leverage current offerings across existing programs and include focusing on the supporting infrastructure of cloud systems: Databases, Linux OS, and Networking.

Three cloud certification-focused courses were combined with the foundational courses to form the complete the college credit certificate in enterprise cloud computing (CCC-ECC) and the associate degree with a concentration in enterprise cloud computing (AS-ECC) pathway options. The rationale for creating these two pathways versus another four-year degree was a matter of both speed and the lack of a framework for a four-year degree program in cloud computing in the state frameworks. Additionally, this addressed two student populations; currently employed IT professionals returning to academia for upskilling with the CCC-ECC, and traditional college students enrolling in the AS-ECC program.

Curriculum Design

The core curriculum design for cloud computing leveraged the existing pathway for an associate degree in computer networking, and partially pulled courses from the design of the bachelor's in information systems technology degree (Figure 3).

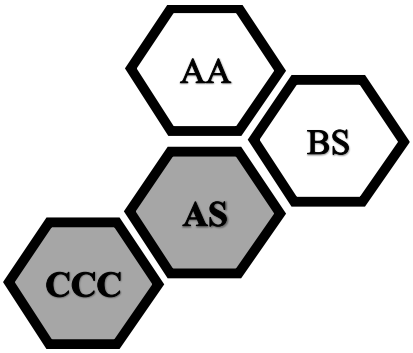

Figure 3. Integration of new cloud pathways.

Using the above-mentioned foundational courses, the three cloud-specific courses added were: Cloud Essentials for the AWS Cloud Practitioner and Cloud Infrastructure and Services for the

AWS Solutions Architect certifications. A project-based learning capstone class completed the pathway with industry experiential projects (Table 1).

Table 1. Core Course Sequence Guide

Courses	**Requirements**	**Certifications**
Databases	-	-
OS Linux	-	CompTIA Linux+
Networking	Co-req CE	CompTIA Network+
Cloud Essentials (CE)	-	AWS Cloud Practitioner
Cloud Infrastructure and Services (CIS)	Pre-req CE	AWS Solutions Architect - Associate
Cloud Computing Capstone	Co-req CIS	-

The course sequence was designed in conjunction with an AWS Educate team. The Educate staff assisted in the design of course sequencing and degree plans to leverage educational experience in teaching cloud technologies. The core of basics of cloud technology parallels a typical datacenter and work focus: Common online operating system used to run workloads (Linux), networking to understand how networks, IP addressing, and security all work to connect to compute resources, and fundamental database design and implementation need to store and process data. These courses can be taken in any order and have been pedagogically adapted to use cloud resources.

The first cloud specific class, Cloud Essentials, introduces AWS cloud basics, and foundational cloud terminology. The next in sequence is AWS Cloud Infrastructure and Services paired with a Capstone co-requisite. This class introduces AWS essential services and their applications in architecting complex business solutions. The co-requisite capstone class, a project-based learning course pairs industry project mentors in the building of real-world cloud solutions. The layered introduction and course design, from the basics of business system components, deploying these designs in cloud-based systems and overall architectures has been used by other higher institutions in the country to develop their own cloud degrees.

In addition to the core courses, elective courses in python, security, and cyber security, all part of the associate program, are recommended to fully explore more aspects of cloud development and design. Python is highly recommended due to its modern design and inherent usability in working with data intensive projects, streaming analytics, stream processing (IoT). Python pairs with the core functionality of many pivotal cloud technologies [14]. To better prepare students, foundational courses are adapted to utilized cloud-based resources, shifting from the traditional local computing resources to cloud-based scalable on demand computing resources. Pedagogical changes were made to utilize project-based learning, incorporating resources and learning from multiple sources in order to best mimic real-world application, data, and design attributes. This

education and systems shift comes at a time when emerging technologies such as cybersecurity, big data/data analytics, AI/ML rely heavily on cloud technology.

Digital Pedagogy

The tools used in the cloud courses are selected to provide a variety of resources and modalities for student success.

1) AWS Academy. Educator portal that provides a ready-to-use curated curriculum, labs and resources targeting transitioning technicians to specific AWS Cloud Certifications. In order to use Academy resources faculty must be AWS-accredited instructors.

2) AWS Educate. System with access to virtually all AWS cloud resources in a simulated environment. Faculty request virtual classrooms and are able to deploy assignments and resources with low risk and no cost to the class.

3) A Cloud Guru. Premier multi cloud training group that provides lectures, labs and current events, to earn a variety of certifications.

4) Whizlabs. System that provides training and practice certification tests for individual and corporate use.

5) On-Demand AWS Tech Talks. These tech talks highlight various parts of AWS infrastructure, case studies, implementation discussions and more to expand the basic knowledge of AWS services and resources.

AWS Academy labs, examples and use cases provided, give the faculty and students a structured AWS set of tools and materials to cover the basics needed for certification. Combining AWS Academy with Whizlabs and A Cloud Guru lectures and tools, allows for differentiated instructions and viewpoints on certification basics. They all offer the opportunity for flipped classrooms, allowing faculty to focus on practice and reviews, with core lectures, and practice performed before limited class time. All these tools together provide faculty an enhanced learning environment with lecture, self-paced practice, hands on activities as needed to promote student engagement and success.

AWS Educate platform is a free form environment that faculty use for cloudification of foundation courses. As examples, the database class can deploy various relational and non-relational databases as needed, with no local lab setup, maintenance or student software installations. In the Linux class, it provides access to multiple Linux virtual machines and labs, giving opportunities for risk free exploration of the manipulation, installation and utilization of Linux tools.

Survey Methods

Student Survey & Analysis

Students who were enrolled in the advanced cloud computing course, known as Cloud Infrastructure and Services, were requested to complete a survey on their feedback related to the cloud computing program overall, the industry certification they earned, and considerations for the future of the program, including ways to improve the program. Thirty-seven of the 39 students enrolled in the Spring 2020 course completed the survey. Once the survey was closed, data was exported from the software into 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.

Faculty Focus Group & Analysis

The virtual focus group took place in May 2020 with faculty who participated in professional development and are teaching the cloud courses. Seven faculty members participated in the 90-minute focus group. Participants were identified by the program leadership. Data collected from the focus group was 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 group 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.

Limitations

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 [15], [16]. 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 [17]. Findings that have been corroborated through triangulation tend to be sufficiently robust and credible [18].

Selection bias is inherent in the sampling methods deployed for the faculty focus group. To address the threat of non-response, the Evaluation Team relied on the program leadership to recruit faculty for the focus group. 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 faculty, 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.

Key Findings – Discussions and Outcomes

The key findings are drawn from a faculty focus group, student survey, and self-reported certification results. The faculty focus group gathered feedback on the professional development they received, as well as on the implementation of the new cloud program. Seven faculty members participated in a 90-minute virtual focus group. Key findings from the focus group are shared in this section. The student survey gathered feedback from 37 out of 39 cloud students enrolled in the advanced cloud computing course associated with its capstone course in Spring 2020 term. Key findings related to overall program satisfaction, pedagogy effectiveness and exam preparedness are shared as well.

Faculty Professional Development (FPD)

1) The suite of FPD offered was more valuable than the one-and-done trainings. Faculty members noted that for this initiative, the FPD that was offered brought together all the teaching and learning approaches that they know work for students. One faculty stated, "It brought together synchronous, and asynchronous, and team learning, and a carrot and a stick…we met the people from AWS who developed the curriculum and we saw some teaching methods." Faculty stated that having "those two modalities – online and face-to-face" was the most beneficial. They also reported that the holistic approach was more valuable than any of the individual PD sessions, as they were able to "spend some time on your own getting comfortable with the materials – how would you teach it? what would you do?" They observed that they were able to work the FPD into their own workloads and that had it "just been face-to-face, and then go take the test, I wouldn't have been ready. And that if it had just been online, it would have constantly been pushed to the back." Another faculty member explained, "This was there to support us throughout the process." This FPD series worked much better than previously offered FPD, remarking that there was "follow up to help us work together, and alone […] which really made it practical and possible." They explained that the trainings from AWS were the most useful, as they provided all the necessary tools and trainings.

2) Certifications earned by faculty are viewed more favorably by both students and college administration. Faculty observed that students are aware of the certifications their instructors have earned, stating, "when we step into the classroom and the students see that we are certified in what we're teaching them, they are a little more engaged." Additionally, faculty remarked that for the first time, they are able to apply the training and certifications earned through this initiative towards the additional graduate credits needed for internal promotion opportunities. They noted that in a dynamic and changing field like cloud computing, the need to prepare and learn new things for class is ongoing. "I don't teach in a static field," explained one faculty member, "Skills change all the time and the prep that I have to do for class to remain current, there wasn't a structure to recognize that effort previously." They noted that this initiative has helped to change the perception of the trainings received since "it is recognized in the college as an effort worthy of counting towards promotion."

3) The FPD offered has enhanced the ways in which faculty teach their classes. Faculty reported that the teaching styles that they experienced in their FPD, the mix of online and face to face "allowed us to work as professionals, meet our current objectives, and be flexible enough to add in the studies, which really gave me some ideas about how to enhance and move towards a blended style of class." Faculty noted that they have enhanced many of their classes, not just the cloud classes, to include more of a blended teaching model. One faculty member remarked that he has moved all of his database classes into the AWS cloud databases, rather than on a server. Another faculty uses AWS Cloud9, a cloud-based IDE, for the Linux and programming courses. Additionally, faculty noted that the FPD offered has provided them with the ability to teach their specific content areas with a cloud perspective, and that the FPD "helped to broaden my view of the computing/IT field. Often times, people have a strict view of what they're teaching but they don't offer a perspective of what's going on in the computing/IT world. Using this training, we can present a different perspective to the students."

Teaching Cloud Curriculum

1) The Cloud computing is an ever-evolving field, which presents challenges for teaching content to students. Faculty noted that one of the challenges of teaching in the cloud computing field is "it's always changing. This is not an area of "I learned it last summer, therefore it's still valid in the spring." They reported that Amazon, for example, is constantly putting new information out on their Slack channels about new technology, enhancements, and updates to existing program. "Everyone is ramping up like there's no tomorrow," they explained, "You stay fully up-to-date on the slice you want to play with, and then stay regionally up-to-date on everything else." They noted that they can't become complacent. "You have to always study,"

they reported, “It’s almost like working in the field, because as new technologies emerge, you have to learn them so you can teach them.”

2) Faculty are not teaching students every new development or update from the thought leaders in the field. Faculty noted that with the evolving nature of cloud computing, they cannot teach students every new update or development because “it would be impossible.” They explained that they “pick a baseline and teach to the baseline. You can’t teach them everything. There’s a fundamentally foundational level to all these classes that says this is the core as it currently stands. I can’t worry about getting them to most current or advanced pieces; it’s not at the level that they need to know.” Another faculty member echoed this sentiment, stating “it’s about 60% core, the things that they need to know, and then we can add in new things.” They remarked that by focusing on the basics, they are positioning students to be able to adapt and understand the changes that are inevitably coming. The online trainings provide context regarding the driving concepts that are utilized, and faculty expressed that “if you can help them understand the basic concepts, they’ll understand what is coming and why.” Faculty concluded that “our job is to give that overview, and once they get a job, that’s where they’re going to go in and become and expert there.”

3) A flipped classroom approach is often necessary for teaching cloud computing. In most cases, faculty reported that students will have to do some work on their own before coming to class. Class time can then be used to “go over it. We need the ability to talk and walk them through what you are doing, and more importantly, to demonstrate it to them. We can walk through an actual database.” They noted that the ability to demonstrate during class time in invaluable, but that it requires the students to be prepared when they attend classes. Faculty also reported that this approach allows for less lecture and more time to “have them work in groups, so they can learn from each other.”

4) Once students earn certifications, they are able to get jobs before completing their education. Faculty noted that they understand the value of the certifications for the field but are concerned about students finishing their education. One faculty member explained, “Because everyone here got the certifications, we understand how good they are,” and another agreed, “The AWS certifications are highly esteemed.” Still, while the certifications that students earn allow them to be well-positioned for jobs, some faculty remarked that there is a risk in students earning certifications before they complete their college programs and then leaving their educational pursuits for employment opportunities. “One thing that worries me a little” explained one faculty member, “is that they’re very marketable, but once they get the certifications, they can get jobs, and it is hard to get them back to finish their degree.”

Problem-Based Learning (PBL) Approach

1) PBL affords students the opportunity for real-world problem solving as they learn. Faculty observed that when using PBL, they work to ensure practical application, saying “it’s real world, real problems, and real solutions to problems, based on getting them involved.” Another faculty member noted, “I use it to bring more real-life examples to connect with the class, so the students can see how this knowledge is applied in the real world. PBL is an excellent tool to practice what [students] are learning.” They explained that it is hard for the students at the beginning since “they don’t know how to solve this right away,” but the more they get involved with it, the more they improve. As one faculty member summarized, “We’re passing agency to the student, to learn how to solve the problems.” Faculty stated that when teaching computing classes, it is “very easy to run through an entire program, and then tell them to go do it.” Though, with PBL, students are instructed to “go research and extend this, to make it more useful in real world settings.” They observed that PBL allows students to “learn something, it’s not just being regurgitated.”

2) It can be difficult to create industry-based projects for students. As the cloud computing field continues to evolve, there is a need for the projects to continue to change. Faculty reported

that they would like to bring in more problems from real companies to the students, explaining, "if we could have local companies interested in having students work on their problems, that would be awesome." Faculty continued, "The hardest part with any large-scale solutions type project is that it spans so much business knowledge and as a professor, that's hard for us to come across by ourselves. You need really good case studies that you can use as a guideline, or you need partners in industry." Faculty noted than when they have had the opportunity to bring industry partners in, or take students on field trips to employers, "it really helps the students see it from a different perspective."

Program Outcomes

1) Student Profile Snapshot. Students were predominantly male, two thirds of the students reported a Hispanic ethnicity, and half of the students were 18-24 years old. One third of students reported that they are first generation college students, 41% are dual enrollment, and none of the respondents were veterans (Figure 4). Nearly half of the cloud students, 46%, are employed in either a full or part time capacity or are involved in a paid internship. Twenty four percent of these students reported their work is in a cloud-related field.

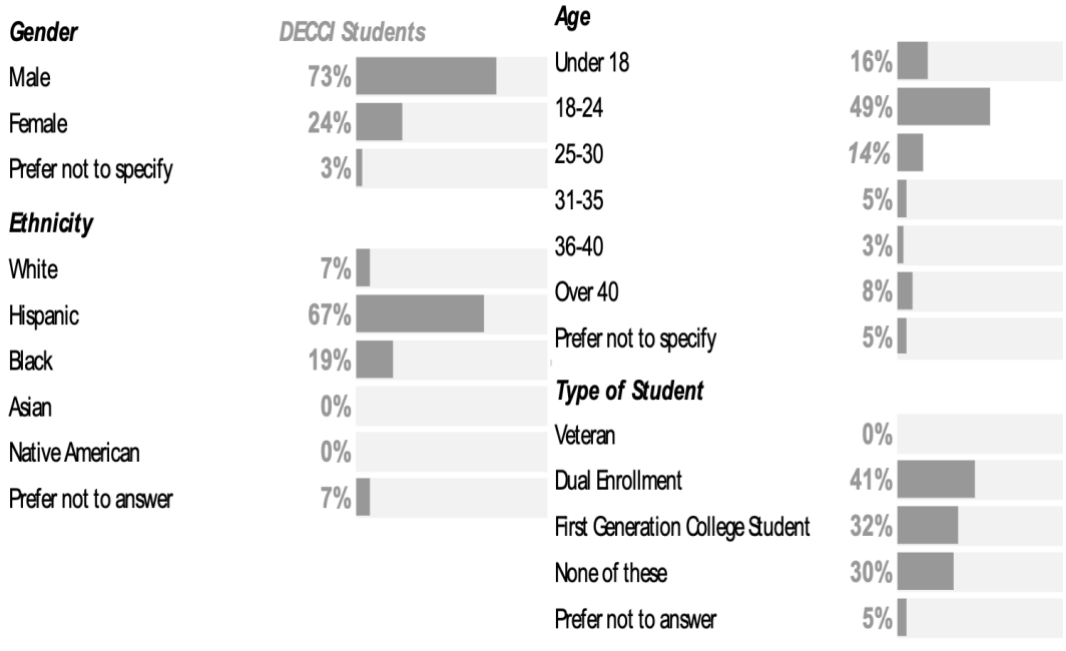

Figure 4. Student Demographics.

Nearly half of the students, 49%, reported that they were taking cloud courses to upskill, while 40% reported that they were interested in the topic (Figure 5). When asked what interested them in pursuing a certificate in cloud computing, the most common theme in responses was preparing for the future. Students noted, "Cloud is the next big thing within the Tech field, and I want to be ahead of the game," and "it is a relatively new field, and has much room for expansion. I would love to be part of its expansion." Several students' responses were related to the theme of the job opportunities that would be available to them once they earned a certificate. One student reported, "I needed something to boost my potential in a tight market," and another noted "I want to advance in the IT field as much as possible, IT is an ever-expanding career field, and I won't be left behind."

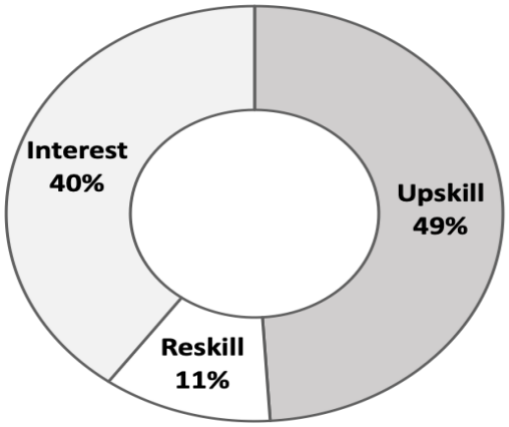

Figure 5. Rationale for Taking Cloud Courses

2) Overall Program Satisfaction. Ninety-two percent of students reported that that were either "very satisfied" or "satisfied" with the cloud program. Additionally, 95% of students stated that they were "very likely" or "somewhat likely" to recommend the program to a friend. The most frequently reported positive aspects of the program were related to the learning opportunities afforded to them, "the program offers students a variety of concentrations (networking, databases, security). Though it's done in a unified manner, the program gives students the ability to find one specific area of interest in cloud computing" reported students. Students also noted, "being able to walk away with more opportunities" for cloud-based job positions and "a positive and helpful learning environment and the supplies needed to learn" as the most positive aspects of the program. Students also noted that the instructors were the most positive aspect of the program, "definitely the teachers, they have gone to great lengths to explain what we are supposed to know and have made it fairly easy to understand." Others echoed this sentiment, stating "the teachers that taught us AWS were great – very helpful and approachable," and "the ability to work together as a group, including the teacher, to learn and grow [was the most positive aspect]." Other reported responses included exposure to a new career field, the opportunity to earn industry certifications, hands-on learning, and the materials provided.

3) Pedagogy Feedback. Students reported that all materials were useful as they prepared for the industry certification exams. Almost 100% of the students found instructor teaching and habds-on projects to be the most useful to their cloud learning journey (Table 2).

Table 2. Pedagogy Effectiveness

	Helpful	**Neutral**	**Not Helpful**	**Did not use**
Instructor Teaching	97%	-	-	3%
Hands-On Projects	97%	3%	-	-
AWS Lecture Notes	83%	11%	3%	3%
Test Banks	86%	3%	-	11%

Fifty-seven percent of students reported that they participated in some sort of work-based learning opportunity through the cloud program (Figure 6). Internships were the most frequently cited opportunity.

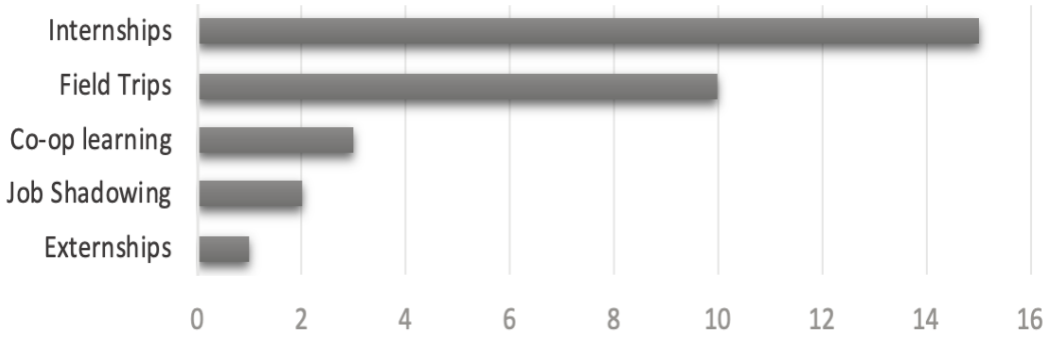

Figure 6. Types of Work-Based Learning Opportunities.

4) Cloud Industry Certification Preparedness. Students reported levels of preparedness to take the exams as a result of their classes followed a similar trend; more than 85% of students reported feeling "prepared" for the three cloud exams that most students passed on their first attempt (Figure 7).

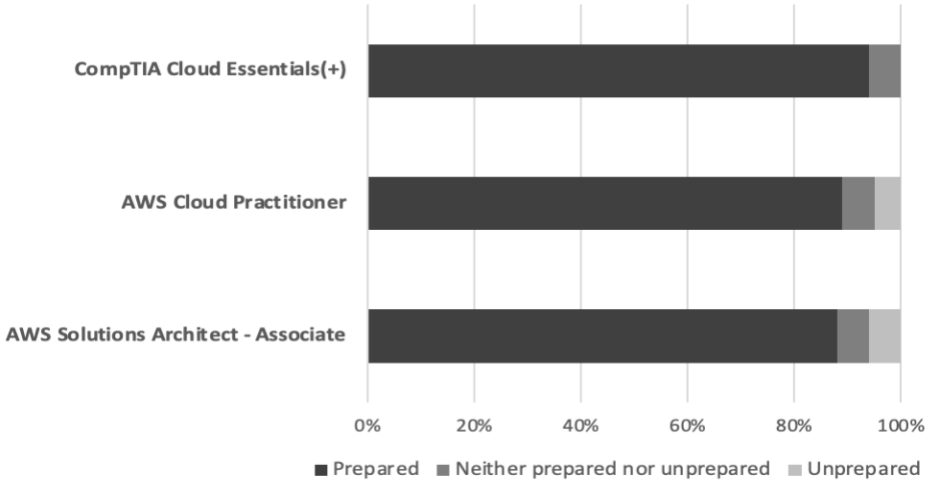

Figure 7. Preparedness for Cloud certifications.

Table 3 provides the total number of cloud-related industry certifications awarded to students who are either enrolled in the cloud academic programs or are taking cloud courses as elective courses part of their computing degree (e.g. cybersecurity, data analytics, information systems technology). The certifications are self-reported by the students who provide the official certification document issued by the cloud provider, and as such the total count for each industry certification may be higher.

Table 3. Cloud Industry Certifications (as of March 2021)

Certification	**Count**
CompTIA Cloud Essentials(+)	80
AWS Cloud Practitioner	111
AWS Solutions Architect - Associate	37

Conclusion and Future Work

The program has already produced some of the first, and youngest, certified cloud practitioners in the country. MDC has created the largest group of certified cloud practitioners in the country at a college. We have certified high school students, some of the youngest in the country, and we have certified solutions architects, coming out of college, as some of the first in the country.

The success of the program and the growing need for not just trained, but skilled and experienced cloud professionals is leading to expand the cloud literacy initiative work by focusing on upskilling current computing/IT professionals with multi-cloud skills in data analytics, cybersecurity, and machine learning specialties. Leveraging new partnerships with Microsoft Future Skills for Microsoft Azure and IBM Skills Academy for IBM Cloud, a group of faculty members completed entry-level training and certifications during the Summer 2020 term to enhance the existing curriculum with multi-cloud computing environments. Future work is to enhance the cloud literacy initiative with the development of advanced multi-cloud courses and degrees in DevOps and Data Analytics.

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