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Enhancing Student Employability in Collaboration with the Industry: Case Study of a Partnership with Amazon Web Services Academy

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Abstract: The continuous increase in tuition fees in high education in many countries requires justification by the university authorities of what students receive from them in return. One of the key factors of student recruitment is values for money and quality learning experiences including hands-on industry training that can guarantee immediate employment for the graduates. This article describes redesigning the curriculum of a cloud computing undergraduate module in collaboration with Amazon Web Services (AWS) Academy. Industry-based practical hands-on labs were incorporated into this module for engineering students to improve their practical knowledge and skills related to the Internet of Things. Through an innovative approach, this practitioner research introduces industry best practices and hands-on labs in cloud computing. In this approach, academic theories were incorporated in cloud computing with their applications through industry attachment. It enables students to have both the theoretical and practical knowledge and skills for ensuring their careers in the field of cloud computing. The study finds that students tend to be more engaged and learn better when theoretical knowledge and understanding are combined with real-world applications through the attachment with the industry.

Keywords: Amazon Web Services (AWS); cloud computing; collaboration; employability; graduate; higher education; industry; partnership; undergraduate curriculum; university; United Kingdom

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1. Introduction

The continuous increase in university tuition fees, especially in the United Kingdom (UK) and United States of America (USA), is a concern for many students, their parents and guardians [1,2]. In the UK, for example, tuition fees have been increased by three times by the previous Coalition Government formed by the Conservative Party (CP) and Social Democratic Party (SDP) led by David Cameron as the Prime Minister and Nick Clegg as the Deputy Prime Minister in 2015 [3]. The implication is that home students (students that are UK or EU citizens) now pay nothing less than nine thousand pounds (GBP 9000 or USD 13,800) per academic year. Depending on the degree programme, this amount could double or triple. In addition, the university authorities are given the option to charge any amount they deem fit for any courses they are offering [3]. International students (students that are not from the UK or EU countries) pay a minimum of GBP 14,000 (USD 17,800) per academic year on average. Universities in the Russell Group charge international students a minimum of GBP 23,700 on an average per academic year for engineering programmes [4]. The same scenario is happening in the USA and some other countries [5]. Because of this rise in tuition fees, parents and students are demanding for improved quality of education through an increase in teaching and learning resources, enjoyable learning experiences, as well as a guarantee for good job opportunities to justify such increases in annual tuition

fees [6]. From the institutional perspective, there is an argument for the justification of an increase in tuition fees for studying engineering courses with the skills needed for employers in the cloud industry.

This article is based on practitioner research that has explored the redesigning effort to enhance the curriculum of a cloud computing module to include industry-focused hands-on labs and best practices as obtained and expected in real-life professional Information Technology (IT) work environments. To do this, a collaborative partnership was established with the AWS Academy, and the first author was trained to qualify as an AWS Certified Cloud Practitioner. This enabled Queen Mary University of London (QMUL) to be registered as an accredited AWS Academy that is qualified to use AWS Academy Cloud Foundations' lecture material, videos, white papers and labs in the delivery of cloud computing modules. As part of the training, students were exposed to various career paths and the opportunities of obtaining an internship or employment after graduation. During the course, AWS cloud computing experts from AWS also supported the lecturers as they delivered hands-on lab sessions to their students.

2. Employability and Work-Based Learning

2.1. Industrial Orientation and Practice-Based Learning

Today's competitive economic environment means that merely subject-specific knowledge is not sufficient for the graduates to secure jobs and sustain their positions. Demands for the skills that will land the graduates employment immediately after graduation are increasing rapidly [7]. Mason et al. [8] defined "employability" as "'work-readiness'; that is, possession of the skills, knowledge, attitudes and commercial understanding that will enable new graduates to make productive contributions to organisational objectives soon after commencing employment".

Several studies have demonstrated that the involvement of employers in designing degree courses ensures the inclusion of appropriate employability skills in the curriculum, resulting in positive change in the graduate employment rate [8]. Work experience or placement during the higher study also leads to a positive learning experience and better employment rate [9]. However, higher education institutions (HEIs) around the world have been going through a transformation over the last decade to accommodate the skills training that is useful for industrial employers to fulfil the demands for skilled workforce. In recent years, new HEIs are emerging, which are designing curriculum in direct cooperation with the industry to ensure better preparedness for learners to meet the needs of the industry [10]. The industry-oriented curriculum includes hands-on real engineering challenges, and the students have the opportunity to work in the industry while acquiring an engineering or technology degree from a higher education institute [11].

The success of engaging industry in curriculum design and delivery to ensure hands-on skills development in any university's education programme depends on how well defined the skills sets are. It also relies on how those skills are embedded in curriculum and practice to fulfil the demands of the industry and how well students prepare through the collaborative partnership [12]. An ill-defined skill set will not result in including the right skills and knowledge into the curriculum and will ultimately not produce graduates that will have the right skills required by the industry. A well-defined curriculum will include inputs from the core industry to ensure that graduates are capable of meeting the needs of the industry to have a well-prepared workforce.

2.2. E-Learning and Hands-on Experience

The investments in higher education by governments, students or their parents and the industry keep increasing expectations to prepare students with the Twenty-First Century skills for the emerging job market through high-quality learning experience [13]. This effort is more visible, especially in disruptive and fast-changing engineering, science and technology fields [14,15]. Some technical domains such as cloud computing, the Internet of Things (IoT), telecommunications, gaming technologies and social media are witnessing

substantial interest in investments due to their economic potential. In order to improve employability of the undergraduate students, some lecturers design and modify the university curriculum to include technical knowledge that has more economic potential [16–18]. A participatory pedagogical approach through blended learning that links theoretical knowledge with practical competence is proven to be effective in knowledge and skills' acquisition and motivating students to learn [19,20].

In most science and engineering disciplines, it is important to blend face-to-face classroom lectures with digital interactions to improve the digital skills of the students as they embark on real-world work experiences [21]. For example, in the cloud computing workplace, almost 90% of the skills required in technical areas are based on virtual resources that have to deal with purely digital interface [10]. The training of students sometimes starts at pre-college stages so that students can master certain basic engineering skills before starting a higher degree at the university level [22]. This can be explained by the popularity of Raspberry Pi, an affordable mini-computer that is used by many secondary schools and universities to implement prototypes of engineering and technology products [23]. Engineering and technology-related subjects are better learned with greater results in terms of knowledge and application of the knowledge in real-life situations through creating and making artefacts and prototypes during the learning and teaching process [24].

E-learning plays a major role in leveraging engineering skills through virtual collaboration, group projects, and the development of software products that can provide students with employability skills [25,26]. The AWS Academy provides e-learning resources in the form of lecture materials, videos, labs, and assessments in their learning management system (LMS), which is used in the cloud computing industry. This creates an authentic learning environment for QMUL's cloud computing students, as reported by some researchers in similar experiments and studies [27]. The e-learning environment can give teachers some visibility on students' performance, as one can visualise and see marks of quizzes or labs performed online in real-time.

The e-learning platform if regulated with an in-house curriculum can provide student engagement and a performance prediction platform [28]. This is usually possible because e-learning environments are designed as multi-user and multi-disciplinary platforms to cater for multiple users in different subjects [29]. For example, the AWS Academy LMS allows different users to use different learning resources such as lecture slides, videos, assessments and labs in different subject areas such as cloud computing, machine learning, deep learning, IoT, autonomous vehicles, big data, data analytics and many others. These multi-user and multi-disciplinary learning platforms are created with employers' skills and knowledge requirements to fill in positions where the skills and competence are in short supply [30]. In the case of AWS Academy, it actually knows the industry requirements as it is the largest provider of cloud computing resources in the world [31].

2.3. Student Engagement and High-Quality Student Experience

A good and intuitive e-learning platform with a well-defined dashboard is also required to help learners during training [32]. User-friendly and easy-to-use dashboards are important components of any successful e-learning technology. This helps learners navigate through the lecture materials, videos and labs without much problem. Some dashboards even go as far as having areas where tutors can monitor how active and engaged students are using the LMS and, by using some data analytics tools, can predict the likely performance of students in the subjects [33]. In addition, some LMSs include some social aspects in some disciplines to create a relaxing environment for learners, creating a kind of all work without play makes Jack a dull boy and all play without work makes Jack a mere toy. This is why some researchers have decided to include social cloud computing as part of LMS to motivate and enhance cloud computing students [34]. This creates some fun so that the learners may forget about the difficult and abstract nature of programming tasks. This has the potential for giving a lively and interactive atmosphere to the teaching of science, technology, engineering and mathematics (STEM) using virtual labs [35]. The LMS of the

AWS academy used in this study has interactive audio and videos of assessments and labs, which make learning interesting and enjoyable.

3. Context of the Study: Designing Cloud Computing Lectures

The natural thing to do when designing the curriculum for an undergraduate module of a degree programme is to consult the vision and mission statements of the university in addition to the core topics that are taught in similar modules by other universities. In this study, Queen Mary's University of London (QMUL) has an established Teaching Excellence Framework (TEF) and strategic aims [36]. There are six main aims under the QMUL's strategy, namely people, research, education, international, public engagement and sustainability. Of these six strategic aims, the ones that fit into QMUL's collaboration with AWS Academy are people, education, public engagement and sustainability. QMUL's aim for people means recruiting staff and students with great talents and potentials and nurturing these talents for greater and more successful careers. This article concentrated on identifying the talents and potentials of students and using the AWS Academy to nurture their future careers through hands-on practical skills that will make them readily employable as fresh graduates in the labour market.

To provide quality education, state-of-the-art technology in cloud computing is adopted using the AWS Academy LMS, which is the most widely used cloud platform and largest cloud provider in the world [31]. The scientific and theoretical background of distributed computing and architectures and the concept of high availability are included in the curriculum to give students a solid scientific and theoretical background. There are three labs designed to test students' understanding of virtualisation, scalability, availability, big data, data analytics and monitoring systems in cloud computing environments. These labs bring the theoretical classroom lectures to hands-on practical implementation and enable students to better understand the theoretical concepts as applied in real-life context. There is a test in the labs for students to attend. This test is meant to validate the level of understanding of the practical implementation by the students. The labs and the test constitute 25% of the total exam marks. This is to encourage the students to take the labs seriously. With the creation of the Institute of Coding (IoC) by the UK government in 2018, the study included the concept of teaching for employability into the curriculum. To do this, emphasis was placed on the career paths in cloud computing during lectures. A diagrammatic representation of skills that match with different career paths and how to acquire those skills was created which is explained later section in Figure 4.

On QMUL's international and public engagement, AWS was engaged to deliver world-class industry-based lectures using videos and assessments in face-to-face classroom lectures, as well as using AWS and QMUL's online LMS platforms. The study looked at similar curricula taught in cloud computing in other universities around the world. For example, the course contents of cloud computing modules and courses offered at the Universities of Edinburgh, Bristol, California Berkeley, Oxford, Cambridge and Stanford were consulted to come up with an internationally acceptable curriculum. It was found that in most cases, there are three main areas covered in their curricula. These are core distributed topics such as scalability, computer cluster, data centre design, virtualisation, MapReduce/Hadoop and big data/data analytics. The study decided to add topics such as Graphics Processing Units (GPUs) and Computed Unified Device Architecture (CUDA) programming as these technologies are now playing important roles in providing high-performance and energy efficiency in computation and data processing. Figure 1 below shows the key cloud computing professions linked to the skills and pre-requisites that students need to obtain to be successful in such professions. This is a concept that provides students with a road map in their journey towards employment after graduation. It is a kind of decision tree that maps each professional career path to skills requirements and how to acquire those skills.

Figure 1. The AWS Academy Cloud Foundations Virtual Labs for QMUL lecturers and students.

The professional career paths in cloud computing are so many that this study cannot provide an exhaustive list in a diagrammatical form, but only present the most popular career paths. Table 1 shows nine popular professional (see Column 1) paths in cloud computing that the study emphasised in teaching for employability. The columns for training requirements and knowledge prerequisites describe the training and skills students need to succeed under each professional path [37–39].

Table 1. Career paths and skills requirements in cloud computing.

Professional Career in Cloud Computing	Training Requirement	Knowledge Prerequisite	Approx. Average Salary
Cloud Deployment Engineer	SOA, design patterns, system reliability/availability, web services, scalability, container technologies	JavaScript/JSON, scripting, programming problem-solving skills in IT, ability to acquire new IT skills	£55,000
Virtualisation Engineer	Xen Hypervisor VmWare, web services, system scalability, web services, OSs, container technologies	JavaScript/JSON, scripting, programming problem-solving skills in IT, ability to acquire new IT skills	£66,500
Cloud Security Specialist	Security technologies (PKI certificates, SSO) cloud security models (AWS shared responsibility model)	Cybersecurity awareness installations/configurations problem-solving skills in IT, ability to acquire new IT skills applications/OSS patching	£69,500
Cloud Administrator	Linux/Windows troubleshooting, container technologies	Scripting (Bash, Python, Perl), command-line programming in IT, problem-solving skills creativity, ability to acquire new IT skills	£79,500

Table 1. *Cont.*

Professional Career in Cloud Computing	Training Requirement	Knowledge Prerequisite	Approx. Average Salary
Cloud Solution Architect	SOA, design patterns web services, system reliability/availability, web services, scalability, container technologies network technologies (router, balancer)	JavaScript/JSON, scripting, networking (CISCO), problem-solving skills in IT, ability to acquire new IT skills	£101,000
Cloud Network Engineer	Design patterns, network technologies (CISCO), VmWare scalability, Firewall	JSON, Skills in subnet problem-solving skills in IT, ability to acquire new IT skills	£77,000
Cloud Developer	SOA, design patterns, middleware, development environment, scalability, web services, container technologies	JavaScript/JSON, Object Oriented Programming (OOP) problem-solving skills in IT, ability to acquire new IT skills	£86,500
Big Data Specialist	Database technologies, statistical applications, mathematical skills, data cleaning, data analytics tools	Scripting, SQL/NoSQL, statistical packages, problem-solving skills in IT, ability to acquire new skills	£77,500
DevOps Engineer	SOA, design patterns, web services, content management skills, development skills, container technologies	JavaScript/JSON, Object Oriented Programming (OOP) problem-solving skills in IT, ability to acquire new IT skills	£90,000

The common requirements for all the professional tracks in cloud computing include creativity, problem-solving skills and the ability to keep acquiring new skills. These common attributes are emphasised during teaching as cloud computing are constantly evolving. This was also reflected in the teaching and lab contents of the module as they were constantly reviewed in collaboration with the AWS to ensure timely adoption of the latest innovations and technologies. After explaining the professional career paths and the future of cloud computing to students, the next step was organising a class workshop with students in groups to discuss their skills and the career paths they would like to pursue. By doing this, the students were already thinking of what they wanted to do after graduation. In addition, there was a logical justification of engaging with the industry for the increase in tuition fees as the students have a better understanding of the earning potential of their employment after graduation.

4. Objectives of the Study

The objectives of this study were to:

- Incorporate cutting-edge industry cloud technologies into the curriculum to encourage hands-on proficiency for students;
- Explore the benefit of the industrial attachment for cloud computing lecturers to get trained as AWS professionals.

5. Preparation of the Intervention: AWS in Cloud Computing Module

The AWS Academy has put in place criteria for any university or institution of learning to use its teaching and learning materials. The first stage is the registration of the lecturer(s)

into the AWS Academy's Cloud Foundations programme. The first author registered for the course and spent about 12 weeks studying the lecture slides, videos, assessments, white papers and labs. After feeling confident with the materials and hands-on practical labs, he registered for the AWS Certified Cloud Practitioner (ACCP) practice exam using the AWS free voucher. AWS requires that all lecturers and instructors that are preparing to sit for any AWS certification exams have a short online video workshop given by their senior technical manager. This important workshop shows how to go through the materials that need to be covered by the lecturers before the exam and how to revise materials and what the exam process looks like.

It is expected that the lecturers will in turn do the same to their students after passing the certification exam. Using the 50% discount AWS voucher for the ACCP exam, the first author took the exam and passed and immediately registered QMUL as an accredited AWS Academy. Having gone through the certification training themselves, lecturers not only have the confidence in delivering lectures and labs to their students, but have the confidence of their students as they display their certification qualification and logos. This is similar to the recommendation that UK university lecturers need to acquire the Fellowship of Higher Education Academy (FHEA) qualifications as an indication of their proficiency in learning and teaching. This also justifies the increase in tuition fees, as it will be seen by student and their parents that the university only recruits academically and professionally qualified lecturers.

The next stage is choosing the teaching and lab materials of the AWS to be included in the curriculum of the cloud computing module. The AWS Academy's LMS provides different sections for setting up virtual classrooms, lecture slides in Microsoft PowerPoint (PPT) and Portable Data Format (PDF), videos of the lectures, assessments after each lecture to validate understanding, white papers, practice exam questions and labs for each accredited university. The LMS is divided into student and instructor areas, where students can download slides and watch videos and do their labs while instructors can do all of what students can do in addition to setting up classrooms and monitoring the progress of students' labs. For example, it is customised in a way that lecturers can send notification messages to students that have not started the labs or have started, but have not finished, and tutors can see students that have started and completed their labs. There is also an area where digital certificates are stored when any student or instructor appears for the certification exams and passes. There are also digital certificates for completing each of the main modules. Another area is the section to register for practice and actual certification exams. This area allows students and instructors to schedule exams at different AWS exam centres around the world and pay for the exam registration fees. The LMS has a complete view about training up to exams and certifications. This makes the students not only think about the training, but also the certifications leading to a potential future career in cloud computing.

The model of collaboration in the Joint Programme (JP) between QMUL and Beijing University of Posts and Telecommunications (BUPT) is that lecturers from QMUL fly to Beijing to deliver lectures. For every semester, each lecturer may teach for about four weeks, making at least four trips to Beijing. Each module (e.g., Cloud Computing) consists of at least a total of 40 h of teaching workload, which is delivered within the four-week duration. Each teaching week is 10 h, delivering 2 h of teaching every day during the 5 days of teaching in a week. In addition to lectures, there are labs and coursework. The coursework constitutes 25% of the total marks, while the final exam is 75%. With this distance arrangement, the need to use online virtual lecture materials and labs is very important, even though all lecturers must deliver lectures in person. Using QMUL's LMS known as the QMPlus for announcements and uploading some AWS teaching materials, real-time quiz analytics that pops up five questions at the end of each lecture and gives a summary of the choices made by the students, which give the students and the lecturer an idea of the level of understanding of the topics covered in the lecture, was created.

A group work task for designing scalable and highly available cloud infrastructure is given to students in groups of five. A collaborative QMPlus functionality known as the QMPlus Hub is customised and used by each group to communicate and share codes and designs using a single view of their final product. This enables them to work on the project at any time and from anywhere that they can have access to the Internet. In addition to using QMPlus, the AWS Academy LMS is used for teaching, conducting assessments and labs. Because QMUL is an accredited AWS Academy, a dedicated virtual classroom and labs have been created for QMUL lecturers and students. The lecturer, who must be an AWS-Certified professional, is given administrative privileges to activate and deactivate classrooms and labs and can view the progress of students on the lecture materials, videos and labs. The students can register in a class or lab using their QMUL's email addresses only. This is to conform with the requirements of AWS Academy, which allows only students from accredited AWS Academy institutions to use the system. Figure 2 shows the tab that QMUL lecturers and students that are registered with the AWS Academy Cloud Foundations can click and see all the courses, modules and labs. As can be seen, 174 students were registered for the course.

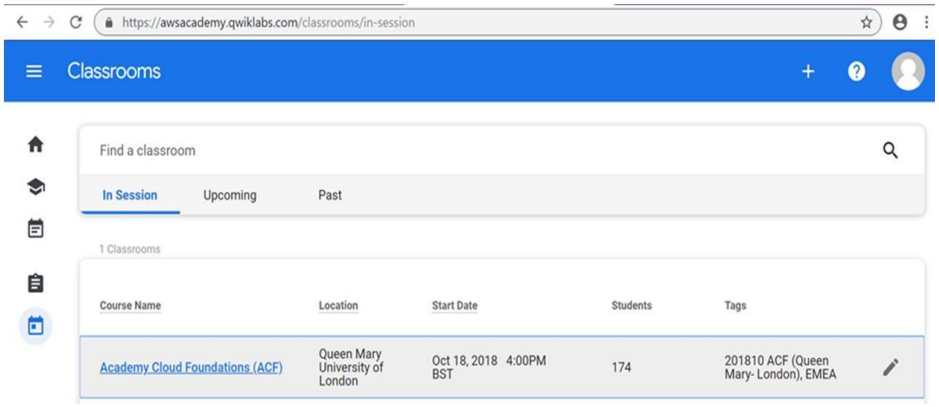

Figure 2. QMUL's AWS Academy Virtual Classroom [40].

Clicking on the QMUL's classroom displays details of the five modules. Each module consists of a series of audio presentations and assessments. The system is configured in a way that when a student completes all the materials for a module, the student automatically gets an email that congratulates the students on completing the module and assessments. The five modules consist of corresponding five labs with titles starting with ACF Lab 1 to ACF Lab 5, as shown in Figure 3. Each lab lasts for two hours. AWS Academy issues students with credits (valued in USD) that allow them to do the labs. Unlike other users, students that register for the ACF under this program do not need to register their debit/credit cards during registration.

The labs are customised in a way that the instructions that the students need to follow to do the labs are presented on one tab and the actual labs in another tab that are completely on separate web pages. This makes navigating between the two web pages sometimes problematic. To get around this problem, QMUL wrote a simple script that calls the APIs of these two web pages and presents them as one web page with the instructions on the left side and the labs on the right side, This innovation has improved the ease of use and reduced the time normally taken to finish the labs by 20%.

The cloud computing labs have been going for the past four years now. When the module was created in 2014, the lecturers were using physical servers that Teaching Assistants (TAs) need to install open-source software (OSS) such as OpenStack, VirtualBox, Apache Tomcat Container, MySQL, J2SE or J2EE and many other software. Every year, the TAs had to reinstall and update the software as there were always problems with versions of the applications and labs not working properly. However, with the adoption of the AWS Academy Cloud Foundations' lab materials and platform, there are no more issues with

updates or upgrades of software or hardware. This has saved 60% of the time TAs used to spend on installations, updates and administration tasks for the labs. In addition, students do not need to come to the physical labs to do their labs, but can do them anywhere they have access to the Internet.

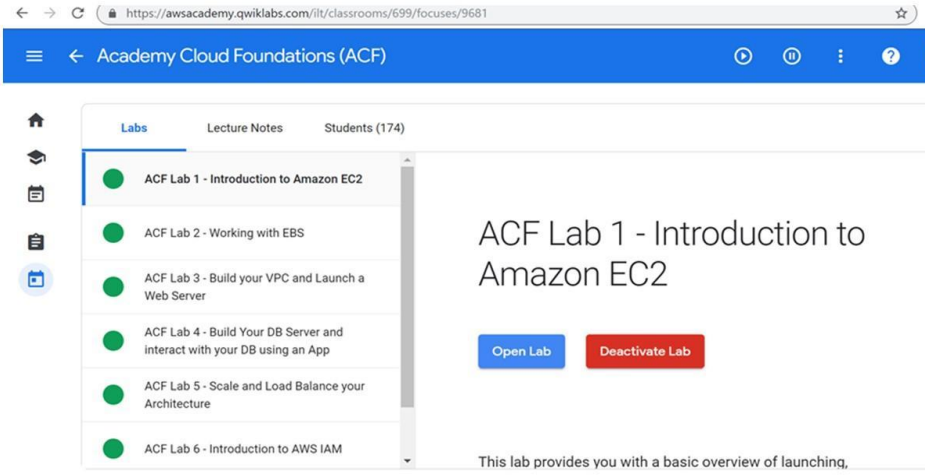

Figure 3. The AWS Academy Cloud Foundations Virtual Labs for QMUL lecturers and students [40].

6. During Intervention Activities and Levels: Teaching Cloud Computing for Employability

The whole concept of introducing industry hands-on practical skills and best practices of the state-of-art in cloud computing into the academic curriculum is to make students at QMUL stand out in the crowded global labour market from students that just acquire theoretical knowledge. Apart from keeping up with the fast-changing technologies, collaborating with the world's largest provider of cloud computing services and using their materials to teach students not only justifies the increase in tuition fees, but gives the students the confidence they need to go out there and start working without any experience. The first confidence boost comes from the fact that the lecturers/tutors that are teaching the students have themselves gone through training by AWS Academy and have appeared at the certification examinations and passed. Passing the certification examinations ensures the lecturers' necessary proficiency in the associated theories and the practical applications as the labs. This is important since the labs are tailored to be hands-on to complement the theoretical lecture materials. During lectures, the professional certification and some key professional paths as created by AWS Academy are emphasised to create that awareness of employability routes in the students' minds from the beginning. This part of teaching uses Figure 4 for illustration.

AWS Academy Cloud Foundations is the training that helps the students prepare to take the AWS Certified Cloud Practitioner examination. This is the foundational certification that serves as the prerequisite for other higher certifications. The other certifications after passing this foundational exam as shown in Figure 4 are the associate-level AWS Certified Solution Architect, AWS Certified Developer and AWS Certified SysOps Administrator certifications. At the professional level, there are the AWS Certified DevOps Engineer and AWS Certified Solutions Architect certifications. Others at the speciality level include AWS certifications in Advanced Networking, Big Data, Security, Machine Learning and Alexa Skill Builder. These certification routes are emphasised to the students and the skills required with incentives and remunerations enjoyed by these professionals that work for AWS and other companies. The idea is to prepare and stimulate the students' ambitions towards obtaining those jobs of their dreams by combining both academic and professional qualifications. With the inclusion of 25% of the lecture materials and two out of the six labs of AWS Academy Cloud Foundations in the cloud computing curriculum, the students

already have about 25% of training in the AWS Certified Cloud Practitioner exam materials. However, this is not sufficient enough for the students to pass this exam.

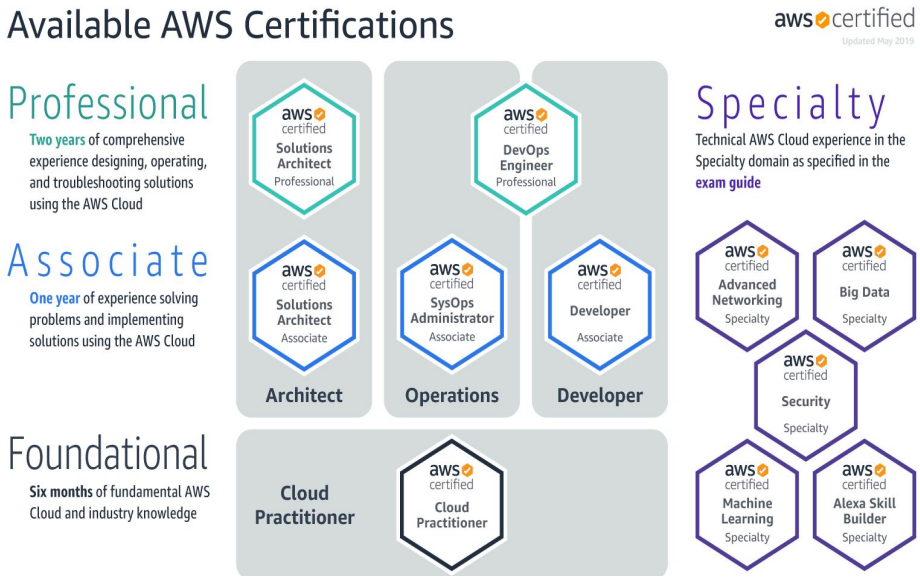

Figure 4. The AWS Certification and career routes [40].

The lecturer arranged extra sessions for the students which was not required by the university to ensure that the students are well trained to feel confident to appear in the AWS certified cloud practitioner examination. This is going beyond the university curriculum for the cloud computing module in terms of the lecture materials, assessments and labs. This is necessary if students must acquire both academic and professional knowledge and skills in technology-driven qualifications that will earn them certifications in different professional paths. This means that as lecturers, there is the need to stretch resources to give students the best education they deserve. The sacrifice paid off as the students appreciated the extra time and efforts put in to increase their competitiveness in terms of employment. In addition, this effort endeared the lecturer to the students, as well as earned students' respect and confidence. Earning the respect and confidence of students as a lecturer is a key to the successful delivery of lectures as the students feel happy and comfortable to attend lectures and listen to the lecturer with interest and enthusiasm.

When students complete the AWS Academy Cloud Foundations' training (all the lectures, videos, assessments and labs), the students automatically receive electronic certificates of completion sent to them in the transcript area of AWS LMS. The satisfaction of obtaining a certificate from the biggest cloud services provider in the world gave the students additional satisfaction and the urge to go ahead and write the practice and final exams.

7. Research Methodology

7.1. Design

This is a small-scale mixed-methods empirical educational interventional study to explore undergraduate students' hands-on learning in partnership with the industry. As the intervention, the curriculum of a cloud computing module was redesigned and enhanced in collaboration with the AWS Academy to incorporate the latest cloud technologies in lecture materials and labs [40]. The study was carried out when the AWS Academy Cloud Foundations was introduced in the 2018/2019 academic year.

7.2. Methods

This study adopted both quantitative and qualitative data using a systematic approach to collect data using questionnaires, attainment data and personal reflection on curriculum

redesign and teaching practice. Based on the survey method, this study administered two separate questionnaires with students who took the cloud computing module to collect data. The first one was administered at the beginning of the module delivery, and data were collected based on an online questionnaire using the widely known platform SurveyMonkey. The second one was administered after the completion of the module, and it was a paper-based questionnaire. Two questionnaires were conducted with the same cohort of students. There were 10 questions in both questionnaires. Some of the questions were close-ended, and some of them were open-ended. The first questionnaire was aimed at exploring the opinions of students on the inclusion of the AWS materials into the cloud computing curriculum and whether the students were interested in completing all the course materials so that it can enable them to prepare and appear in the AWS Certified Cloud Practitioner examination. The link of the first questionnaire was sent by emails to students at the beginning of the course. The second questionnaire was administered face-to-face immediately after the students had completed their cloud computing module examination.

7.3. Research Participants and Sampling

Purposive sampling [41,42] techniques were used for collecting data. Therefore, students who took the cloud computing module were chosen as the participants of this practitioner research. The total number of students in the cohort was 166. Among them, 96 students participated in the first questionnaire survey and 30 students participated in the second questionnaire survey. Out of the 166 students who were sent the survey via their email addresses, 58% responded to the first online-based questionnaire. It took time to achieve this response and required constant reminders to the students to complete the questionnaire. Since many students were interested in becoming AWS-certified cloud practitioners, the additional materials that were not included in the cloud computing curriculum (and hence, were not taught to the students) were delivered to them to better prepare for the certifications. Around 30 students attended these five extra lectures on AWS Academy Cloud Foundations. The second questionnaire was a paper-based survey and was distributed immediately among these students on the last day of the extra lectures. The response rate was 100%. The students filled in the questionnaires and handed them in to the tutor before they left the classroom.

7.4. Data Collection and Analysis

This study adopted a systematic approach to collect data using questionnaires, as well as practitioner reflection on curriculum redesigning and teaching practice. To decide about curriculum redesigning, these surveys covered a selected part of the cloud computing module, which focuses on students' training and certification. This will ensure that they become professional IT experts in areas that are in high demand in the IT industry.

7.5. Ethical Concerns

Consent was given by the students during data collection for both online and paper-based surveys. They were briefed about the project, and it was ensured that no harm would be done to any of the participants. It was also clearly mentioned to them that they had right to withdraw from the study anytime during the course delivery and until the end of the academic year 2018–2019. The collected data were completely anonymously, and no personal data were collected.

8. Results

8.1. Quantitative Attainment Data Analysis

The inclusion of the AWS Academy Cloud Foundations in the curriculum of the Cloud Computing module had a positive impact on the performance of the students, as shown in the results of the examination. The final marks for the exam consisted of three parts—the examination, labs and the class test. The examination constituted 75% and the labs and the test 25%. A total of 166 students appeared at the exam, and 90.80% passed the exam

(only 9.20% failed). Of this result, 42.94% obtained distinctions (A grades). This is the first time that AWS materials were introduced into the cloud computing curriculum. This study conducted a comparative analysis of the performance with the two previous years' results. Figure 5 demonstrates the results of this comparison.

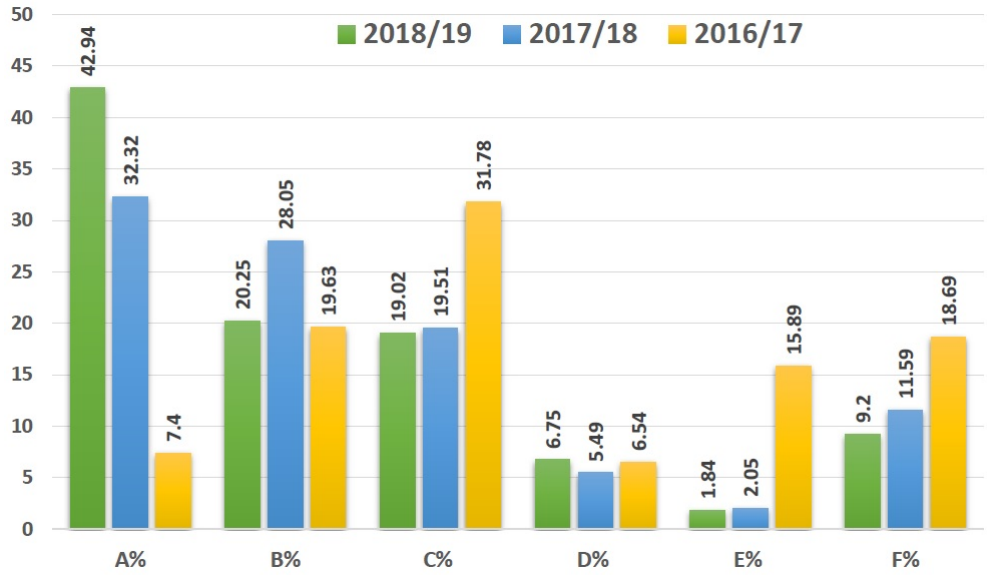

Figure 5. A comparison chart of 3 years of results of the Cloud Computing module.

Figure 5 shows that more students (42.94%) obtained A grades (distinctions) in the 2018–2019 academic year than the two previous academic years 2017–2018 (32.32%) and 2016–2017 (7.4%), respectively. The results also showed that the failure rate in 2018–2019 reduced to 9.20% compared to the two previous years, which had 11.59% and 18.60% failure rates for the 2017–2018 and 2016–2017 academic years, respectively. The improvement in performance and reduction in the rate of failure in the module are attributed to the fact that the students now had the theoretical knowledge backed up with the hands-on practical real-life implementation. It was ensured that AWS course lecture materials and their implementation in the AWS ACF labs reflected that combination.

This study and other studies showed that students can easily relate exam questions to what they have done in the labs and real-life scenarios and can easily remember the answers in an examination situation [43]. For example, students used to just memorise the mathematical equation for calculating the high availability (HA) of computer nodes in a cloud environment. However, with the explanation given in the AWS Academy materials, students now know that actually, HA means having more redundant options in different physical geographical regions and availability zones of a cloud provider to allow system failures to recover much quicker.

8.2. Data from the First Questionnaire

From the respondents, 83% of the students thought that the inclusion of the AWS course in the curriculum of cloud computing enhanced their learning experience, as well as their understanding of the module. As this survey was conducted at the beginning of the module, less than half of the students (45%) said that they know the career paths to take in cloud computing. However, they were very positive about the inclusion of AWS contents, and 72% of them wanted more of the AWS contents included in the cloud computing module. Interestingly, less than half (43%) said that they would like to attend the additional AWS lectures and labs after their exams so that they can prepare adequately for the AWS Certified Cloud Practitioner exam. Because of partnership agreement, AWS Academy has offered a 100% discount to all the students that want to take the mock tests, but only 38% of the students said they wanted to appear the mock test. Towards the end of the survey,

there was a question focused on instructor's professional certification. The students were informed that the instructor himself is a certified AWS practitioner. More than half of the participants (55%) responded positively about having an instructor who is professionally certified from the vendor. Table 2 provides the summary of the students' responses from the first questionnaire.

Table 2. Student responses (in percentage) from the first questionnaire.

Question	Yes %	No %
Inclusion of the AWS course into the curriculum of cloud computing has increased their learning experience	83	17
Know the cloud computing career paths	45	55
Would like to attend the additional AWS lectures and labs after their exams	43	57
Wanted more of the AWS contents included in the cloud computing module	72	28
Would like to participate in the mock test	38	62
Having an instructor who is professionally certified from the vendor	55	45

8.3. Data from the Second Questionnaire

There were 80% of the respondents who said they are now more confident in using cloud computing resources and technologies after attending all AWS lectures. There were 83% who said they now know more about cloud computing career paths. There were 90% of the respondents who said they would like to appear in the final AWS Certified Cloud Practitioner exam if they passed the practice exam. For a question on the justification of the increase in tuition fees featured, 70% of the students responded positively subject to certain conditions being fulfilled. They also thought that most courses should include hands-on practical and professional content that enhances the quality of the education and improves their confidence, as well as employability.

There were 90% of the students who said they would like to be recommended for internships where they can implement what they have learned in the AWS training into practice. Around 85% of them thought that cloud computing has a very promising future for students that can acquire cutting-edge training in cloud computing. The AWS ACF training and these two surveys have opened a whole new perception on how to teach cloud computing to future students. This also gives an insight into how to make students appreciate the increase in tuition fees. During the course, they were made aware of the potential career paths (see Table 1). They were also encouraged to explore the job market online. They were also asked about their perception of the job market. Above 75% of the respondents felt that there were huge opportunities for cloud computing-related jobs after graduation. Table 3 provides the summary of the students' responses from the second questionnaire.

Table 3. Student responses (in percentage) from the second questionnaire.

Question	Yes %	No %
More confident in using cloud computing resources and technologies	80	20
Knows more about cloud computing career paths	83	17
Interested in appearing at the AWS Certified Cloud Practitioner exam	90	10
Justification of increase in tuition fees	70	30
Interested in internship if recommended	90	10
The cloud computing profession has a promising future for students	85	15
Huge opportunities for cloud computing related jobs	75	25

9. Discussion

From the quantitative attainment and survey data, it is clear that students' understanding and learning experience in the subject increased when they were exposed to real-life applications of their theoretical knowledge and skills. It could be argued that this is more so in technologically disruptive disciplines such as cloud computing and IoT, as the curriculum needs to be constantly updated due to the constant development in the field and to meet the current engineering and technological requirements of the industry. The survey findings also showed that students' learning experience increased because of the inclusion of industry-based topics in the curriculum and industry attachment. The Students performed better on their final exams compared to the cohorts of teh two previous years. This is indicative of the impact of the redesigned curriculum through the intervention of the collaborative partnership with the industry. In addition, students thought that collaborating with the industry to teach them life-oriented practical skills made them feel that the increase in tuition fees is justified.

Materials and labs with higher relevance to the cloud computing industry were chosen for inclusion in the syllabus. These areas included administration and management of Elastic Compute Cloud (EC2) instances (90% of respondents said this is important), cloud network skills (75%), cloud security (85%), scalability and load balancing (76%) and cloud economics (78%). Approximately 25% of the examination questions and coursework that final-year IoT engineering students appeared were taken from the AWS materials. Because the AWS LMS consists of interactive videos and hands-on practical labs, the students found it easier to understand difficult concepts in cloud computing (e.g., the calculations of high availability, fixed and scaled-up efficiencies). This was demonstrated in the examination results, as there was an increase of about 3% in the passing rate and a reduction of 2% in the failure rate in the cloud computing exam as compared to the results of the previous year (2017/2018).

At the end of the training, about 18% of the students registered their interest to be given the free AWS Academy vouchers to take the AWS Certified Cloud Practitioner practice exam. All 20 students that sat for this exam passed. This performance further justifies the efforts put into the training and goes a long way in making the students appreciate the increase in tuition fees. This gave the lecturer the confidence to recommend the students for internship positions with Alibaba Cloud and other tech companies. The recommendation for the internship is meant to give the students the opportunity to put into practice the skills they have acquired and also to prepare them for real-life professional careers in the future.

9.1. Implications of the Study

There are implications of this study for the colleagues within the STEM disciplines and beyond. As the tuition fee raised, students became more concerned about embedded employability skills in their curriculum, especially those who were studying professional

degrees [44]. Therefore, the engagement of industry in curriculum development and enhancement is pivotal for industry-oriented degree programmes. The framework for engaging industry proposed by Manwaring and colleagues [45] indicates that a high level of engagement happens when industry engaged in course curriculum review. In this case, that is what happened. Findings from this study support the argument for industry–university collaboration in curriculum development and partnership for enhancing teaching and learning through real-life industry experience. For acquiring knowledge, as well as developing appropriate skills and understanding, students need a well-planned preparation for engaging in industry settings and require guidance from their teacher and mentoring by professionals from the industry during their real-life learning experience.

This study showed that by reflecting on individual's practice, a lecturer could learn new skills and better facilitate his or her students' learning by creating opportunities for students to engage in redesigning curriculum for enhancing teaching and learning process [46]. Therefore, from the institutional perspective, arrangements should be in place to increase the capacity of lecturers through targeted staff training programmes for redesigning course curriculum involving students and the industry so that students will have the experience of working with industry to keep up with the emerging skill sets for a particular profession.

Findings from this study could be used to create opportunities for students who completed their industry experience through their experiential learning cycle, where they will be able to gain experience and then reflect on their experience for theorising and carrying out further experimentation. Teachers who teach STEM subjects need to redesign their course curriculum with industry so that students have the opportunities to strengthen their theoretical knowledge through practices with a growing understanding of the interplay between theorising and practising as it relates to engaging with the real problems of the workplace [47].

9.2. Limitations of the Study

There are limitations in this small-scale practice-based intervention study. These are as follows:

- In Chinese educational culture, the teachers' practice and performances are not usually critically evaluated. Therefore, through the traditional questionnaires or face-to-face interviews by the teacher, it might not be possible to elicit students' views about their teacher and his or her pedagogical approaches to the specific content delivery.
- This practice-based practitioner research also has a limitation where there could be student–teacher power dynamic issues that might impact the authenticity and quality of the generated data.
- This study did not explore how students engaged with the learning materials and facilities provided by industry [48]. Therefore, a comparison cannot be made between the previous course curriculum and the redesigned curriculum. An experimental design with experimental and control groups from the same cohort could be a good way to address this limitation.
- Furthermore, it should be mentioned that due to limitations in terms of access and communications once they graduate from the programme, it was not possible to collect personal data on their employment and future career involvement.

The full AWS training content was not covered in the redesigned module curriculum. When some students showed their interest in completing the rest of the AWS training component, the first author of this article spent an extra two weeks teaching them the entire AWS certification content. However, this study did not explore why other students opted out of the further training to complete full AWS certification content to sit for the certification.

9.3. Further Exploration

This article is the first experiment with AWS Cloud Foundations' LMS, lecture and lab materials in the cloud computing module at QMUL. After the findings of this study are fully implemented, next step will be to explore the impact of the inclusion of AWS curriculum on the students' theoretical and hands-on knowledge in cloud technology. This exploration will ultimately improve the quality of cloud computing graduates and their employability status. Further work will also need to include the inclusion of more advanced AWS Academy topics from the AWS Academy Cloud Architecting materials to see whether that will help the students acquire necessary knowledge to become AWS Certified Solution Architects. However, this requires the lecturers train to be certified on the AWS Cloud Architect track as this is a prerequisite of the AWS Academy. Further study will also explore the impact on the employability of enhanced university-industry collaboration where AWS and other cloud providers may offer students internship opportunities. This may give the students more real-life work experience and may also enhance the employability skills of students to secure a job immediately after graduation. Further exploration can also involve finding appropriate ways to encourage more students to eventually take the certification examinations.

10. Conclusions

As technologies quickly change, it is essential to introduce fast-changing technologies to students by redesigning curriculum and adding new teaching materials every year. This enhancement endeavour ensures that graduates are ready for the job market with appropriate skills set. This article highlighted the benefits and opportunities of collaborating with the industry to have access to cutting-edge cloud computing technologies for inclusion in the cloud computing curriculum. The AWS is the largest cloud provider in the world, and its AWS Academy provides training to educators around the world to become certified cloud practitioners.

The university-industry partnership of this intervention resulted in better student performance in the attainment of the module compared to the examination results of two previous academic years. Results derived from empirical data showed that the students had more confidence in using cloud technologies, and they thought that the increase in tuition fees was justifiable after the inclusion of the AWS Academy Cloud Foundations in the cloud computing curriculum. The students also thought that the hands-on practical skills they acquired in the AWS Academy labs increased their employability. It is evident from this educational interventional study that working with the industry to design the curriculum created better learning experiences and improved the skills and confidence of the students. In addition, the students performed better in the examination when exposed to the real-life practical aspects. It prepared them well with the skill sets, and thus, they felt more confident about securing a job immediately after graduation. Through this university–industry partnership, they also learned about the different career paths. Engaging in partnership with Amazon provided students another opportunity to learn about the certification.

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