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PAPER

Challenges and Opportunities in Cloud Computing Education: Saudi Arabia Case Study

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ABSTRACT

The complexity of cloud computing development often presents significant challenges for junior software engineers. Our mixed-method study examines the challenges, motivations, and importance of acquiring knowledge and practical experience in cloud computing for junior software engineers before they enter the job market in Saudi Arabia. Furthermore, our work highlights the necessity of revising traditional educational approaches by integrating practical projects into the curriculum, as well as addressing challenges related to cost and accessibility.

KEYWORDS

software engineering, cloud computing, junior software engineer, mixed research design, digital education, learning and management systems (LMS)

1 INTRODUCTION

As technology continues to advance, the role of software engineers becomes increasingly pivotal in shaping and building the complex systems that drive societal progress and global connectivity. Software engineers follow a staged process that follows a software development life cycle (SDLC) consisting of requirements, design, development, and deployment phases [1]. However, the development process with the emergence of cloud computing has different procedures, standards, languages, and frameworks as well as encompasses a diverse ecosystem of services, architectures, and tools, each designed to address specific challenges and opportunities [2].

Fresh software engineering graduates from traditional software engineering programs are well-versed in fundamental programming and development concepts. However, upon entering the job market, they often find themselves grappling with their limited understanding of cloud technologies acquired during their academic studies. This underscores the critical importance of empowering junior software engineers with the necessary cloud skills. Given that it is a valuable skill set for

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modern software engineers, there is a need to revise traditional approaches to focus more on cloud infrastructure concepts and methodologies.

This paper is organized as follows: In section two, we conduct a literature review to understand the history and related works. In section three, we introduce the research methodology, motivation, and research questions. In section four, we present our findings and discuss future work.

2 LITERATURE REVIEW

In the early 2000s, cloud computing [2], a new concept in software development gained popularity. With the high demand for acquiring such skills in the job market, some research examined how to integrate cloud computing into higher education. Previous research found that there is a need to revise some concepts in software engineering to make them more aligned with cloud computing, such as teaching the software development lifecycle in the cloud [3].

2.1 Cloud computing history

Cloud computing is a transformative technology that has revolutionized the software engineering field. As an overview of this technology, the US National Institute of Standards and Technology (NIST) offers the following definition of cloud computing: "Cloud computing is a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction" [4] [5].

Cloud computing encompasses three service models: software as a service (Saas), platform as a service (Paas), and infrastructure as a service (Iaas). Saas provides complete application, data service, and all the essential platform and infrastructure elements via the internet. Paas provides platform-level resources, including the operating system and software development framework. Iaas provides fundamental infrastructure, including physical machines, virtual machines, and storage [6].

Cloud computing service providers have continued expanding their regions to new regions. We are witnessing the establishment of hyperscale cloud regions in various Middle-East countries, such as Saudi Arabia, the UAE, Qatar, Kuwait, Oman, and Bahrain. This development is marked by investments from prominent cloud providers, including Amazon Web Services (AWS), Google's Google Cloud Platform (GCP), Huawei, Microsoft's Azure, and Oracle [7].

2.2 Challenges in teaching cloud Computing

Junior software engineers often encounter several challenges when attempting to acquire cloud computing skills due to several reasons. One of the reasons is that the teaching methods used for teaching software engineering are based more on theoretical education more than practices. [8] previous studies discussed that teaching theoretical concepts is not enough and there is a need for students to acquire practical skills [9].

Furthermore, building familiarity with different cloud platforms can be costly and challenging for junior engineers, especially students [10]. Finally, the cloud ecosystem is wide-ranging and continually progressing [11], comprising various

service models (IaaS, PaaS, SaaS) and providers (e.g., AWS, Azure, Google Cloud), thus students may find it overwhelming to grasp [12].

2.3 Teaching approaches

Cloud computing platforms are becoming a new draw for higher education students [13]. Many studies have investigated methods to enhance cloud computing education [14]. Universities start to include cloud computing curriculums in their learning systems [15], [16] by emphasizing the fundamentals and infrastructure aspects of cloud ecosystems and requiring students to complete these courses once annually during their studies [17].

Furthermore, some educational institutions are spreading the culture of adopting cloud computing for teaching and learning among their faculty members. The institutions provide intensive training sessions for the faculty members to develop their skills in the use of cloud computing in education [15]. While other universities are encouraging their students to utilize online learning platforms [18]. One way to encourage students to utilize online learning platforms is by giving them complimentary vouchers from various training providers to open up new job prospects for them [19].

One study found that educators and institutions can proactively address the challenges of teaching cloud computing by working together to identify effective approaches to improve cloud education. For example, educators are encouraged to integrate real-world software systems into their teaching methods by incorporating cloud-related projects into the curriculum, providing students with more practical experience [9]. However, when integrating real-world projects into the curriculum, it's important to measure the cost-effectiveness of this approach and ensure that it brings tangible benefits [20].

Combining traditional in-class student activities with self-study using online environments allows tutors and lecturers to leverage the advantages of digitalizing education while keeping the benefit of in-class communication [19]. Online learning platforms can offer flexibility and easy accessibility, as well as acquiring professional cloud certifications from leading cloud service providers [19]. These certifications can ensure that students are well-prepared for industry demands [12].

There are some challenges for universities to include cloud computing curricula. Finding suitable projects that align with the curriculum can be costly for educational institutions and may require access to premium cloud infrastructure and resources [9]. Moreover, not all juniors may have access to digital devices or a reliable internet connection, which can lead to inequalities in educational opportunities [20], [21]. Furthermore, the complexity of the cloud ecosystem can also present a challenge for universities [5], [17], [20]. Training faculty members in cloud-based skills for effective education can be costly and time-consuming for universities, further evaluation is needed to assess whether this training effectively addresses the limitations [15]. Table 1 summarizes the challenges and recommended solutions.

Currently, there is a rise in the number of online communities and users who are dedicated to knowledge exchange and experience sharing in clouds [13]. With this rise, a need for quality control on educational content, as well as there is a need for enhancing engagement in online learning, particularly in comparison to traditional teaching methods. To enhance the quality of knowledge sharing additionally, universities have to examine the accuracy and value of shared information in online cloud-related communities [13]. To enhance engagement, recent work suggests incorporating more interactive content [22].

Table 1. The analysis and evaluation

Challenges	Solution from Literature	Limitation of Literature Solution	How to Address the Limitation
Educational curricula are theoretical more than practice [1]	Integrate real-world cloud projects as part of the teaching approach [1], [3], [23].	Finding suitable projects that align with the curriculum can be costly for educational institutions and may require access to cloud infrastructure and resources [23].	Measuring the cost-effectiveness of integrating real-world projects into the curriculum.
	Leverage online education with broad-range of course materials [4–7].	Not all juniors may have access to digital devices or a reliable internet connection which can lead to unfairness in educational opportunities [8], [9].	Evaluating the availability and diversity of digital education methods to ensure that they can benefit from it.
	Integrating cloud computing curriculums into existing courses [10], [11], and spreading the culture of adopting it for teaching and learning among universities' faculty members [12], [13].	The complexity of cloud ecosystem [10], [15], [16].	Training faculty members on how to integrate cloud-based skills into their courses effectively [12], Also, evaluate the effectiveness of the training to addresses the limitation of integrating cloud computing into education.
	The increase of online communities for knowledge and experience sharing in clouds [15], [16].	Need quality control on information [13].	Ensure by examining that the information shared is accurate and valuable and how the quality of knowledge sharing can be improved in online cloud-related communities [13].
Students are not engaged in learning Cloud Computing [22]	Utilize online learning platforms and courses [6], [17], [18].	Potential lack of engagement compared to traditional teaching.	Add more interactive content can enhance the learning experience [22].
	Acquire professional cloud certification offerings [18], [19].	Cost related to get professional cloud certifications [4].	Utilize the opportunity to receive complimentary vouchers from various training providers, which can open up job opportunities [14].

3 RESEARCH METHODOLOGY

This study was conducted using a mixed-methods approach, as in Leavy's explanatory design approach [24]. Leavy's explanatory design typically involves a sequential process where quantitative data is collected and analyzed first, followed by qualitative data to investigate the current state, challenges, and future trends of learning platforms [24].

3.1 Research motivation

The purpose of this study is to investigate pedagogical methods for teaching cloud computing fundamentals in Saudi Arabian universities. Our research questions are as follows:

RQ1. What are the primary challenges faced by junior software engineers when trying to acquire cloud computing skills in Saudi Arabia?
RQ2. How to improve the learning experience for junior software engineers who are seeking cloud computing skills?

3.2 Data collection and analysis

Firstly, we collected quantitative data through a survey. Then, we conducted semi-structured interviews with cloud experts, software engineer instructors, and

trainers to determine effective approaches and uncover strategies for improving cloud teaching. Following the participants' consent, all interviews were recorded, and notes were taken during the interviews.

The interviews have been transcribed using Google's AI [25]. The qualitative data analysis followed a four-step procedure [26]. Firstly, raw data went through cleaning to ensure accuracy and clarity. Subsequently, the data was systematically chunked and reduced to create a more manageable dataset. The third step involved coding the interviews to identify categories, high-level abstractions, and behavioral patterns. The coding process aimed to extract meaningful concepts and patterns from the transcribed content and compare data points to identify similarities and differences. The coding process was organized using tables and categories, with each code assigned a title [26]. The iterative nature of the review process ensured a thorough understanding of the transcribed interviews. Multiple reviews were conducted, with each iteration revealing new categories. This iterative approach continued until no new categories emerged, preventing any valuable information from being overlooked.

We also provided a descriptive analysis of our population. The data was gathered using demographic questions, multiple-choice questions, and rating scale questions.

The outcomes follow a triangulation design, a unified mixed methods approach where both quantitative and qualitative data are collected and analyzed in a singular phase of the research process [27] (see Figure 1).

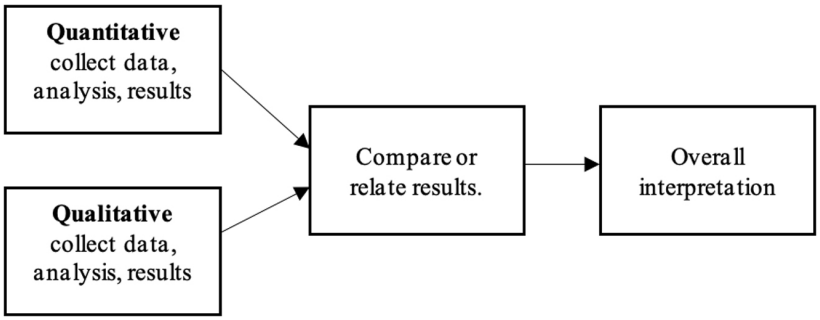

Fig. 1. Triangulation design [27]

4 RESEARCH RESULT

This section represents the findings and outcomes from the gathered data to answer our research questions. These questions seek insights into the primary challenges and the effective utilization of digital educational methods to enhance the learning experience.

4.1 Survey

The total population comprises 24 respondents over 10 days, including (12.5%) male participants and (87.5%) females. The mean age and standard deviation of the participants measured was 29.458 years (SD = 4.3), with the majority falling between 25 and 30 years old (58.3%). The participants represented various majors, with Computer Science (25%), Software Engineering (20.8%), and Information Systems (16.7%). Followed respectively by Information Technology and Cybersecurity (8.3%), Computer Engineering, Business Administration, Studies Information, and Computer and Network Engineering. Regarding educational status,

(83.3%) were graduates, while a small percentage were still undergraduates (Freshman 4.2%, Junior 4.2%, d 8.3%).

Regarding formal education or training in cloud computing concepts, 75% had not received any, while 25% cited self-learning through sources like IBM Data Science Course, EMC Academic Associate, SDAIA Clouders, and a bootcamp at Tuwaiq Academy (Alibaba Cloud Computing).

The primary motivation for acquiring cloud knowledge was to meet market demands (87.5%). Moreover, other motivations included personal interest, job requirements or needs, and career advancement. Additionally, some participants highlighted that *"It helps understand the basics of technologies and learn other technologies faster such as AI and ML"* and *"To keep up with the advancement in technology and understand the way it works."*

When participants were asked to rate the difficulty of learning cloud computing on a scale of one to five, where one denoted "very easy" and five represented "very difficult," (4.8%) found it very easy, (14.3%) easy, (52.4%) neutral, (28.6%) difficult, and none found it very difficult.

(57.1%) of the participants indicated that they had taken online courses or attended workshops related to cloud computing. When we asked the participants if they preferred self-learning or instructor-assigned courses, (61.9%) preferred self-registration courses, while (38.1%) preferred instructor-assigned courses. However, when we asked what delivery method they preferred, (4.8%) preferred structured in-person courses, (23.8%) favored online resources, and (71.4%) preferred a mix of both.

When we asked participants to think of a solution that can be customized to their needs with hands-on activities, (38.1%) preferred to have this solution as a standalone system, while (61.9%) favor integrating it with existing learning and management systems (LMS). Additionally, (85.7%) preferred accessing the solution via desktop or tablet, and (33.3%) via mobile devices (refer to Table 2).

Table 2. Distribution of the demographic characteristics of participants

Variable	N (%)	Variable	N (%)
Gender		Age (years)	
– Male	3 (12.5%)	≥ 20	2 (8.3%)
		21–24	3 (12.5%)
– Female	21 (87.5%)	25–30	14 (58.3%)
		30 ≥	5 (20.8%)
Major		Educational status	
– Computer Science	6 (25%)	– Graduates	20 (83.3%)
– Software Engineering	5 (20.8%)	– Undergraduates	4 (16.7%)
– Information Systems	4 (16.7%)	– Freshman	1 (4.2%)
– Information Technology and Cybersecurity	2 (8.3%)	– Junior	1 (4.2%)
– Computer Engineering	1 (4.2%)	– Senior	2 (8.3%)
– Business Administration	1 (4.2%)		
– Studies in Information and Computer	1 (4.2%)		
– Network Engineering	1 (4.2%)		

(Continued)

Table 2. Distribution of the demographic characteristics of participants *(Continued)*

Variable	N (%)	Variable	N (%)
Takes Formal Education or Training		Primary Motivation for Acquiring Cloud Knowledge	
– Yes	6 (25%)	– Meeting market demands	21 (87.5%)
		– Personal interest	20 (85.7%)
– No	18 (75%)	– Job requirements or needs	14 (61.9%)
		– Career advancement	12 (57.1%)
Difficulty of Learning Cloud Computing		Preferred Digital Educational Methods for Learning Cloud Computing	
– Very easy	1 (4.8%)	– Taken online courses/ workshops	12 (57.1%)
– Easy	3 (14.3%)	– Preference for self-registration courses	13 (61.9%)
– Neutral	11 (52.4%)	– Preference for instructor-assigned courses	8 (38.1%)
– Difficult	6 (28.6%)	– Preferred structured educational settings	1 (4.8%)
– Very difficult	0	– Favored online resources	5 (23.8%)
		– Preferred a mix of both	15 (71.4%)
Preferred Access of the learning system			
– Stand-alone system		8 (38.1%)	
– Integration with existing LMS		13 (61.9%)	

4.2 Interviews

The qualitative analysis investigated the challenges and motivations of junior software engineers in acquiring cloud computing skills and gathered insights from interviewees with diverse perspectives within the cloud computing domain. Cloud specialists and practitioners were interviewed.

One of our participants is a recent software engineer graduate from King Fahd University of Petroleum and Minerals (KFUPM), and he works as a cloud engineer at Google. He provides a fresh perspective on entering the field and how the formal education that he received during his undergrad helped him to enter the job market. Our second participant has three years of experience in both DevOps and cloud engineering, and currently serves as a cloud infrastructure developer at Google. Furthermore, we interviewed a cloud trainer, who has fifteen years of experience in Google and AWS. We also interviewed an assistant professor at King Saud University (KSU) with nine years of expertise in software engineering.

First, we examined cloud specialists' interviews. Despite the differences in their experience and background, they shared common challenges in entering the field of cloud engineering. The key points extracted from the interviews underscore the importance of enhancing educational approaches. Furthermore, acquiring knowledge and practical experience before entering the job market is important. This is evident in the case of one participant, a cloud expert, who recently graduated from KFUPM University. He obtained specific qualifications in cloud computing by taking

four elective courses during his final year. He emphasized the benefits of acquiring knowledge and practical experience during his undergraduate studies, enabling him to start his career early.

Another participant emphasized the importance of establishing partnerships between companies and universities for accessible learning material and claiming opportunities for discounts with cloud providers, while the other advocated for a more detailed curriculum and stressed the importance of a structured learning experience through university courses.

Both participants highlighted the importance of understanding the core concepts of cloud computing while acknowledging that there are diverse cloud service providers that require specific skill sets. One participant said, *"Cloud shouldn't be specific to a certain provider. I think you should learn about any type of cloud services. Just understand the concept of it. That would really help you. Just try to focus on the core concept itself and try to avoid a vendor lock-in. You don't want to have all your projects all in one cloud provider in case, let's say, the provided services go down."* He advised students to avoid vendor lock-in.

Consequently, examining the interviews with technology education specialists, an assistant professor in the software engineering department with nine years of experience and a Google Cloud Trainer with fifteen years of experience shared a common ground and differences in their perspectives on cloud teaching. Both express a strong interest in integrating cloud computing into formal curricula, emphasizing a practical, hands-on approach to teaching. They jointly recognize a gap between theoretical knowledge and practical application, supporting the inclusion of cloud-related content in undergraduate studies.

Despite differences in educational settings and teaching experience, both of them emphasized that there is a need for more cloud computing specialists in the current job market, besides the need for instructor-led courses. While the assistant professor emphasized improving teaching methodologies, the trainer emphasized the need to bridge the gap between theory and practical knowledge. Their recommendations highlight the importance of encouraging undergraduate students to engage in practical activities, with the trainer proposing a specific 60% theory and 40% hands-on ratio. Additionally, both interviewees stressed the need for collaboration with the industry and provided detailed guidance on navigating cloud providers and market trends.

Additionally, the trainer highlighted the importance of selecting the right cloud provider based on regional strengths. He said, *"For Saudi Arabia, right? Google is very strong. In Southeast Asia, especially Singapore, AWS and Azure is very strong. Most of the customers, most of the enterprise customers are moving towards these two players. So, [it is important to] look at trends, [and] one's needs."*

Overall, the results show common challenges and common grounds in entering the field, suggesting partnerships between companies and universities, integrating practical, hands-on cloud teaching in formal curricula, and understanding core cloud concepts. The educational specialists also highlight the gap between theoretical knowledge and practical application, suggesting improvements in teaching methodologies, and recommend a balanced approach of theory and hands-on learning.

Collectively, these perspectives emphasize the need for inclusive and practical cloud education and collaboration with industry in formal settings. Figure 2 illustrates the percentage of interviewees who identified specific challenges in acquiring cloud computing skills. The percentages represent the percentage of interviewees who mentioned each challenge during their interviews.

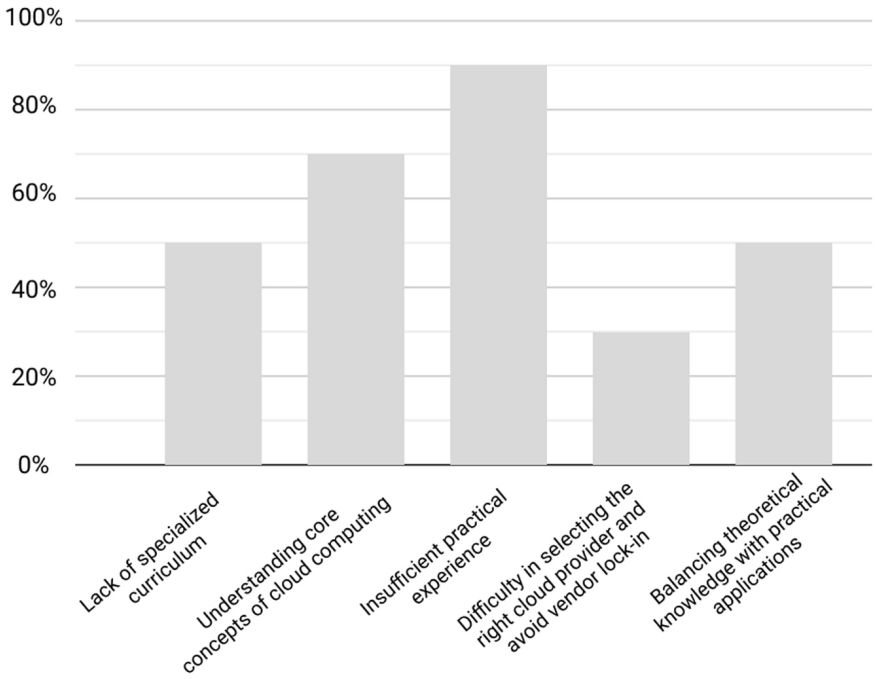

Fig. 2. Challenges faced by junior software engineers in acquiring cloud computing skills

5 RESEARCH DISCUSSIONS

Acquiring both knowledge and practical experience before entering the job market is crucial for undergraduate students, as demonstrated by one of our participants. However, cloud computing education faces several challenges. In our study, we found that formal cloud computing education focuses on theoretical teaching methods that make it hard for students to practice cloud platforms; this finding is aligned with previous research [22]. Furthermore, choosing the right cloud service provider to teach students about it is not a trivial task, as indicated by one of our participants, who said, "*…You don't want to have all your projects all in one cloud provider … let's say, the provided services go down.*" this finding extends previous research [28].

The complexity of the cloud system is another challenge highlighted by our participants and previous work [25]. We suggest that evaluating faculty training is needed [3] to overcome this challenge. Moreover, learning different platforms can be an extra challenge due to the costs of resource usage, as pointed out by the previous work [4], [29]. Conversely, one participant highlighted the importance of exploring all available resources, including the free-tier offerings from major cloud providers, utilizing open-source resources, and YouTube videos.

The study's interviews with cloud specialists, an assistant professor, a cloud trainer, and junior software engineers revealed the challenges, needs, and motivations of junior software engineers in acquiring cloud computing skills. It agreed with the literature by stressing the need for specialized curricula and practical experience [8], [9]. Furthermore, they identify the need for learning the basic skills of the best regional cloud provider [22].

Our survey results aligned with previous works that the primary motivation for junior software engineers to learn cloud computing was to meet market demands [10]. Moreover, they preferred self-registration courses [11].

Moreover, we highlighted the importance of using digital educational methods by mixing theoretical and hands-on approaches as preferred by 71% of participants in the survey results. Following that, the trainer's recommendation was to develop a system with a 60% focus on theory and fundamentals, complemented by a 40% hands-on approach.

However, when we asked participants to think of a solution to solve the learning issue, the majority preferred the solution to be integrated with existing LMS, rather than a stand-alone solution. This provides an important design recommendation for future solutions.

The findings of our study may be influenced by biases from participant demographics, primarily due to the small sample size and the predominance of female participants. This could potentially limit the generalizability of our results. Nonetheless, both qualitative and quantitative approaches provided important insights. We intentionally selected interviewees with expertise in the cloud field to better understand the challenges and motivations.

Future research in the field of cloud computing education could explore various avenues. Firstly, conducting more extensive and diverse studies with a larger number of participants would ensure a broader representation of experiences, leading to a better understanding of the challenges and motivations faced by individuals entering the field. Longitudinal studies tracking participants over an extended period could provide insights into the long-term impact of cloud computing education. Additionally, investigating user preferences for learning systems would be valuable.

6 CONCLUSION

Learning cloud computing technology is necessary for software engineers to acquire the needed skills to meet the demands of the job market. This research investigates the challenges faced by junior engineers while learning cloud computing and their preferred approach for learning. This study emphasizes the need to add specialized curricula with more practical experience throughout the undergraduate years. Furthermore, it highlights the importance of early exposure to cloud technology.

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