Panel: Incorporating Cloud Computing Competences into Computing Curriculum: Challenges & Prospects

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***Abstract*—Cloud computing has emerged to be one of the leading professional competences desired by modern day employers, especially in the computing profession. We use computing as an umbrella term that includes Computer Science, Information Systems, Software Engineering, and other related courses. The benefits and value proposition of cloud computing have made it a desirable course to be taught across computing curricular. However, teaching and learning cloud computing comes with daunting challenges that often discourage educators. As a result, cloud computing is yet to be part of the computing curriculum in a vast majority of higher institutions in the USA; thereby denying students the myriad career and employment opportunities peculiar to their peers with cloud computing skills. The aim of this panel therefore is to analyze the challenges of teaching cloud computing, proffer solutions to those challenges, and develop an approach that can be adopted by computing instructors who desire to incorporate cloud computing competences into their curriculum. In addition, participants will have the opportunity to learn and access resources provided by 'AWS Educate' for teaching and learning cloud computing.**

Keywords—Cloud Computing, Curriculum Design, AWS Educate,

I. Description and Rational

Cloud computing is a utility computing model that provides on-demand access to elastic and scalable IT resources (such as storage, networks, servers, and applications) via the internet [1]. The value propositions and numerous benefits of cloud computing have made it very attractive to contemporary organizations. Popular among these benefits include massive reduction in the cost of IT ownership, which results in economy of scale; optimized planning of organization's IT resources, which offers reduced to no capacity over or under estimation; and flexibility in provisioning IT resources [2]. As a result of these benefits, modern day organizations are increasingly adopting cloud computing as an alternative to traditional on-premise computing or colocation, wherein IT resources are owned, provisioned and managed by the organization itself [3]. Hence, the demand for graduates with cloud computing competences[1] has increased in recent times [4][3].

Currently, there are numerous career opportunities available to graduates with ability to perform basic and advance cloud computing tasks. For instance, on February 6, 2020, the lead author conducted a search, using *'Cloud Computing'* as the keyword, on the 3 popular job portals in the USA, namely *indeed.com, glassdor.com and monster.com*. The results show 22,712; 73,456; and 85,796 respective job openings that require cloud computing competences. However, the vast majority of these jobs are likely to remain open for a long time, or possibly become unfilled, due to shortage of cloud computing skills. Already, there are scholarly reports [3][5] about the current shortage of cloud computing skills and how this, if not addressed, will eventually hurt not only the computing industry, but all organizations across industries.

Usually, the industry depends on educators and academic institutions to produce and supply qualified professionals to meet demands in areas of skill shortage. However, it is evident from extant literature that very few educators and academic institutions are currently making efforts to teach cloud computing competences [6], [7]. Moreover, is very hard to find published scholarly discourse, especially in the leading academic journals and conferences, that focus on teaching cloud computing or incorporating it into the computing curriculum. Yet, unlike other technologies that emerged and disappeared in recent times, or are still in the experimenting phase, cloud computing has been around for approximately a decade. Thus, it is a fair claim that cloud computing has passed the experimenting phase and is now essential part of contemporary computing. Hence, the time to incorporate cloud computing into the curriculum is now and academic institutions and educators are responsible to make this happen [8]. There are many other reasons cloud computing is a desirable course to be incorporated into the computing curriculum. Cloud computing skills are increasingly applicable, and support learning, in other areas of computing and engineering. For instance, AWS Redshift and AWS EMR are cloud services that can be used to teach Big Data and Analytics. Similarly, AWS Fraud Detector can be used to teach Cybersecurity or Machine Learning, while AWS Comprehend can be used to teach Natural Language Processing (NLP). But if cloud computing is so promising, why are academic institutions not responding to the need of teaching cloud computing competences?

Indeed, teaching and learning cloud computing can be very daunting [3]. The high learning curve, coupled with the broad spectrum of competences offered by cloud computing are perhaps, some of the contributing factors. At the basic extreme of this spectrum are cloud technical essentials and practitioner competences, while DevOps and solutions architecting competences are at the advance extreme of the spectrum. Knowing the exact competences to teach and how to design learning objectives to deliver them are challenging initiative. But overcoming these challenges requires that they are confronted head-on through intellectual discourse, championed by academics and practitioners with interest in cloud computing. This is why FIE Conference is a suitable venue for this panel. We expect that the outcome of this panel

[1] By competence we mean skills and knowledge.

will encourage computing educators to incorporating cloud computing courses into the computing.

II. Anticipated Audience

A. Names and Affiliations of Anticipated Audinece

In order to make the desired broader impact in computing and engineering education, we plan to invite a wide range of educators and industry practitioners that have keen interests in cloud computing. Industry practitioners are necessary since they can provide a set of cloud computing competences that are required from graduates. These competences will serve as input to the design of cloud computing curriculum and learning objectives. Most these participants have attended and participated in previous FIE panels[9]–[11] and paper presentations [12]–[14] fall in one or more of the following categories:

- Instructors, lecturers and professors who want to learn and teach cloud computing to students
- Curriculum design experts willing to provide critical perspectives on how to incorporate cloud computing into the computing curriculum
- Industry practitioners, recruiters and ambassadors willing to discuss and share information about cloud computing competences required of graduates by employers
- Researchers and other academics with expertise in cloud computing
- Instructors, lecturers and professors who are already teaching, or have taught, cloud computing and are willing to share the challenges they face, or faced, and what they did to overcome those challenges
- Anyone with interest in cloud computing

III. Goal of the Panel

The goal of this panel is to develop a framework for incorporating cloud computing competences into computing curriculum. In so doing, we aim to address the current cloud computing skill shortage. Accordingly, participants will have the opportunity to contribute solutions to various challenges of cloud computing education. Also, we intend to identify a broad set of cloud computing competences that are required by employers. Then design learning objectives for cloud computing courses that will cover those competences. More so, we intend to identify potential teaching and learning pathways to cover the broad spectrum of competences offered by cloud computing. These pathways are intended to be consistent with the three teaching perspectives proposed by Ian Sommerville[8]. These include sensitization i.e., learning objectives that delivers entry level competences; practice or learning objectives that delivers intermediate competences; and principles or learning objectives that delivers expert level competences. A summary of our goals and objectives are as follows:

a) Analyze and proffer solutions to the challenges of incorporating cloud computing into the computing curriculum

b) Identify a set of cloud computing competences required by employers.

c) Develop course learning objectives and learning pathways for delivering the competences identified above

d) Examine available pedagogical methods to identify those that would be appropriate for teaching and learning cloud computing

To achieve these goals, we intend to adopt an inquiry-based approach, wherein every participant will have opportunities to discuss, ask, reflect and share information with others. Accordingly, the participants will be divided into groups. Each group, made up of 4 to 5 participants, will be required to complete a set of questions and/or activities. Each question or activity will have a direct mapping to the goals and topics covered in the panel. To facilitate effectiveness, each group will have a team captain, who will be responsible for moderating the activities of the team and keeping time. There will also be a team scribe, who will write down the discussions and findings of the team. Finally, there will be a team presenter, who will present those findings to the rest of the participants. The activities and group work will be preceded by a 10 minutes presentation led by one of the organizers. This presentation will focus on how Amazon Web Services (AWS) can be used to teach cloud computing courses. See Table 1 for more details of the Panel Agenda.

IV. Topics to be Covered in the Panel

The topics to be covered in this panel closely align to the learning objectives stated above. Given that we intend to adopt an inquiry-based approach, we structure our topics as research questions, as done by previous panel organizers[10][9]. These questions will be answered through team activities during the panel as discussed in Section III: .

1) What are the prevailing issues challenges, and setbacks in teaching cloud computing?

a) How can these challenges be overcomed ?

2) Which cloud computing core competences are required of graduates from?

3) What are the courses learning outcomes correspond to those competences?

4) What are the learning pathways that can be used to deliver the competences identified above

5) Which pedagogical techniques can be used to best deliver cloud computing competences.

V. Panel Agenda

A summary of the panel agenda is shown in Table 1 below.

Activity	**Time** (Mins)
Opening Remarks--Participants will be introduced, and the goals of the panel will be explained.	5
Presentation--In this presentation, Grant Irons, the Faculty Enablement Office at AWS (Amazon Web Services) will provide overview of the resources, tools and techniques for teaching cloud computing using AWS. Participants will have the opportunity to learn more about the AWS Educate Cloud Ambassador Program	10
Group Discussion--About 4 to 5 participants will be assigned to each group and provided with writing materials to discuss and write down the answers to the five topics/research questions in Section IV. Each	50

group is expected to spend 10 minutes in each question	
Presentation of Result--After the group discussion, we expect each group to make a brief presentation of group answers and findings. Each group will have about 3 minutes for this presentation.	15

VI. List of Supporting Conference Papers

Some of the organizers of this panel will submit the following abstracts for peer-review in FIE alongside this panel.

A. *Teaching Introductory Data Analytics Course Using Microsoft Access and Excel*

This Research to Practice Full Paper provides an approach and practical examples that can used to teach and learn data analytics. Data analytics has been recently adopted by many researchers and professionals working with data in both academic and industry. With the increase in demand for data analysts, there has been a parallel growth in data analytics training programs within companies and educational institutions. In this paper, we introduce the concepts in data analytics and present practical examples using Microsoft Access and Excel. The four types of data analytics (i.e., descriptive, diagnostic, predictive, and prescriptive) are discussed and an example is provided for each type. For descriptive analytics, we discuss the data properties and models and present examples of database design and implementation in Microsoft Access. The example for diagnostic analytics involves an ergonomic assessment application in Microsoft Excel to identify the sources of ergonomic risks in work environments. Predictive analytics examples include regression and clustering models implementation in Microsoft Excel. Finally, the prescriptive analytics example involves optimizing the snow removal process by developing an optimization model and its implementation in Excel. These examples will help students to understand data analytics and be able to implement the different data analytics models in Microsoft Access and Excel

B. *Comparative Analysis of Computing Instructional Methods Based on Professional Comptences*

Computing educators usually adopt various instructional methods to facilitate the teaching and learning process. Examples of popularly instructional methods include flipped classroom, project-based learning, game-based learning. However, there is little or no research studies that have investigated which instructional methods best support the delivery and acquisition of core professional competences by instructors and students respectively. This creates a gap in the body of knowledge and leave some research questions unanswered. For instance, which instructional methods best support instructors to deliver core professional competences such as problem solving, teamwork and critical thinking? Also, which instructional methods best enable students to develop or acquire these professional competences? In order to close this gap, this research performs a comparative analysis of popular instructional methods to identify the instructional methods that best support the delivery or acquisition of professional competences in Computing

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