Cloud Based Environment for Higher Education Institution in Developing Countries

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***Abstract*—Current modern technologies are playing a key role in the development of the higher education sector by providing multiple modes of learning delivery, collaboration and communication. Cloud computing is an emerging paradigm that plays an important role and has major impacts on higher education institutions (HEIs) in developing countries. It enables users to access diverse software applications, share data, collaborate more easily, and keep their data safely in the infrastructure. Despite the intensive use of cloud computing, limited research has been conducted regarding the use of cloud-based environments by HEIs in developing countries. The purpose of this work is, first, to provide a coherent understanding of cloud computing models used in HEIs. We distinguish the various opportunities and challenges emerging from using different cloud computing services. Second, we propose a cloud based-environment where several cloud services and deployment models are orchestrated in order to create a coherent environment containing the necessary tools. This environment puts into practice several expertise fields and deepens the knowledge of both students and instructors. In addition, we demonstrate the effectiveness of our proposed environment through the experience and findings of a Tunisian School of Engineering, where our cloud-based environment is implemented. This school is a private higher education institution founded in 2003, it employs around 500 people and hosts more than 8,000 students. Finally, findings from this study will helps academics, instructors, and researchers understand the potential of using cloud computing environments from an engineering school's perspective.**

***Index Terms*—Cloud-based environment, Higher education institutions, Deployment models, Cloud services, learning practices.**

I. Introduction

Cloud computing is a model for enabling ubiquitous, convenient, on-demand and network access to a shared pool of configurable computing resources including network, storage, servers, and services with minimal management effort [1]. Today, Cloud computing is widely adopted among various industries and educational organizations. HEIs has paid a great interest to Cloud computing for several reasons mainly related to its characteristics. These characteristics present valuable contributions to support learning, research, educational activities, experience exchange, and project development. However, adopting Cloud computing in HEIs gave rise to several challenges. According to [2], the main challenge is how to establish a suitable model presenting an efficient way for using cloud computing in universities, capable of taking advantage of cloud services' features as mentioned above and improving the knowledge acquisition process. In this respect, limited studies have been carried out to address this challenge, particularly in developing countries. Through investigating different research studies [3]–[5], To the best of our knowledge, two main observations are deduced. First, the use of cloud services in HEIs is often limited to one single service or deployment model; in most cases it is a public Software as a Service (SaaS) model. Second, cloud computing is adopted in HEIs based on one single perspective that is essentially related to cloud service features such as cost reduction and high availability. However, cloud computing opportunities in HEIs cover the whole academic process and the way knowledge is acquired. Therefore, a comprehensive cloud-based environment that orchestrates several cloud services and deployment models is capable of improving the learning experience among universities. The above-mentioned observations are often conducted in our work from three main perspectives that present our contributions.

- First, we explore the opportunities which make cloud a powerful and viable technology for universities to adopt in developing countries.
- Second, we propose a model of a cloud-based environment to improve the use of cloud computing in higher education and take advantage of cloud services from multiple perspectives. This is particularly in relation to the learning experience at university in developing countries.
- Third, we demonstrate the effectiveness of our proposed environment through a real validation based on the experience and findings of a School of Engineering in Tunisia.

The remainder of this paper is organized as follows: Section II presents our related work. Section III describes available models for the adoption of Cloud services at HEIs. Section

IV exposes the Cloud adoption opportunities and challenges at HEIs. Section V discusses the present state of cloud adoption of a particular school of engineering. Section VI validates the proposed environment and determines its real impact. Section VII exposes findings and analyzes results. Finally, Section VIII concludes the paper.

II. Related Work

The potential and efficiency of using Cloud Computing in higher education has been recognized by many universities. Despite the efforts made to assist cloud computing adoption in this field, several challenges need further investigation that brings about an efficient model that presents a cloud-based environment able to improve the level of technical and scientific knowledge of both students and instructors.

Currently, there are many practices and examples regarding the use of cloud computing in developing countries. However, the cloud was mostly implemented because of the learning management system and student information system [5] . For instance, in South African HEIs, SaaS is commonly used for student management i.e. admissions, registration, enrolments, bursaries, graduations, and alumni. SaaS is also used for administrative systems such as human resources (HR), customer relationship management (CRM), supply chain, finances, payroll, and asset management. South African's HEIs also use SaaS for learning management systems (LMS), business intelligence and reporting tools, email and office productivity tools such as word and excel [6] .

According to Truong, Pham, Thoai and Dustdar [4] , education institutions in developing countries mainly focus on SaaS services to reduce IT expenditures (electricity, software, hardware, and personnel) which are the high- items of universities' budgets. The same authors argued that universities in developing countries suffer from the lack of communication and knowledge sharing between lectures and students outside the classroom. In [7], the authors investigate the factors that influence student adoption of SaaS services in HEIs in order to generate a set of decision rules to guide through a series of critical decisions needed in this adoption process. They used a survey questionnaire as a method to collect a total of 418 valid questionnaires from students of top-ranked Malaysian universities.

In [8], the authors focused on the importance of cloud computing and big data technologies in managing and improving performance in Egyptian higher education institutions. They proposed a model based on SaaS services to avoid the drawbacks of conventional services and profit from these services that are low cost, easy to use and easily accessible.

Even though the above-mentioned research studies did not took into consideration the importance of using cloud computing in higher education, most of them focused only on a unique service model, namely the SaaS model, offering Massive open online courses (MOOCs), LMS, etc. Moreover, the use of cloud services was related to technical or budgetary opportunities, such as cost reduction and improving services response time. Likewise, only few studies focus on the impact of cloud computing adoption in pedagogical methods within HEIs. These studies also consider the public cloud as the main deployment model to manage their data. This model presents several limits while managing critical and sensitive data. It goes without saying that using the SaaS model and public cloud in HEIs to have access simply and rapidly to several services. However, we strongly believe that using only the SaaS model is not enough to establish a management of knowledge for our students and achieve high academic performance and efficiency in universities.

III. Cloud models for HEIs

The application of cloud services in the field of education may result in great interests for stakeholders involved, including students, instructors, administrative staff, and other key parties to access the services that are provided by these three models.

Cloud computing offers three main service models, which are Infrastructure as a Service (IaaS), Platform as a Service (PaaS) and Software as a Service (SaaS). In this work, we first attempt to provide a coherent understanding about using cloud computing services in HEIs in developing countries. SaaS is by far the most commonly used cloud model in higher education. Its services increase accessibility and sharing of learning resources among students who acquire personal portfolios, assignments and web-based self-services.The most commonly used applications in education context are MOOCs which used by students with disabilities and for lifelong learning, mobile learning, unified communication tools, collaboration tools and storage solutions. PaaS providers offer the ability to self-provision development and testing environments which is much more advantageous for the institutions. They develop applications in collaboration with other developers, architects and designers in the cloud without having to bother about software licenses and without having to own a platform. In addition, they will have the ability to test final services before launching them in a reliable environment that can handle system crashes and without affecting their local resources [9]. IaaS can be used to satisfy the infrastructure needs of the students, instructors or researchers with some specific hardware configuration for a specific task. Indeed, the cloud has been widely used by the scientific community as users can benefit from computing infrastructures at low costs.

On the other hand, selecting a suitable cloud computing deployment model according to the university requirements is a fundamental task since selecting an unsuitable model would negatively affect the relative advantages of cloud computing [7]. The university must decide whether to select a private, public, hybrid or community deployment model.

Private Cloud is deployed within the premise of an institution to provide Information Technology (IT) services to its internal users. It offers greater control over the infrastructure. This is appropriate for institutions that need to be able to access their own resources. Indeed, universities hold vital information of thousands of people and processions includ-

ing; research results and findings that require high levels of confidentiality and privacy [10].

Public cloud model offers full utilization of computing resources; it is more cost efficient and scalable than the other models. It improve access to educational resources for the students [3].

Hybrid cloud computing combines two cloud delivery models, typically private and public. Educational systems are embracing hybrid cloud for the same reasons as businesses. This model helps them gain more flexibility in service delivery and relieve the stress on their IT teams by moving some applications into public clouds [11]. Finally, the choice of the community cloud deployment model for institutions is mainly informed by the fact that they share common Information and Communication Technology (ICT) needs. Likewise, it can be a good option if participation is based on the institution's needs and requirements for infrastructure, business processes, and data management [12]. Community Cloud is also appropriate to institutions who may need to share resources with other institutions [9].

IV. Opportunities and challenges in HEIs

In this work, we investigate the major opportunities and challenges of cloud services. In order to provide an in-depth understanding of this aspect, we explored the literature as the main source for addressing this question. Understanding the opportunities and challenges of cloud computing to improve teaching and learning can potentially increase the extent of interest in integrating cloud-based environments in HEIs in developing countries.

A. Opportunities

Previous studies addressed a number of opportunities for using different cloud computing tools in higher education. However, the benefits of using these tools in such a context were mostly towards collaboration.

1) Advantageous characteristics: The quality characteristics provide a convincing argument for universities worldwide to turn to cloud computing. This part focuses on cloud opportunities in terms of the five characteristics, which add value to the stakeholders needs in HEIs in developing countries.

- Rapid Elasticity: is one of the useful characteristics of cloud computing technology and is considered as a motivator for adoption. The cloud can be dynamically scalable to meet the needs of learning applications and user-scale.
- Broad Network Access: The capabilities and resources are available for both students and instructors over the network anytime, anywhere and using any device which enhances the whole learning experience [13].
- Measured Service: from a financial perspective, cloud computing helps universities cut down the cost due to the option of only paying for what is used [9].
- On demand Self Service: By using cloud based services at HEIs, different stakeholders utilize services to perform various academic responsibilities on demand.
- Resource Pooling: HEIs stakeholders are able to use pooled cloud resources via networks according to their demands [14].

Then, we explore the opportunities of a cloud-based environment to support students, instructors and researchers.

2) Cost-effectiveness: The higher education institution (HEI) is facing the burden of limited infrastructure resources and IT budget, as well as limited teaching staff, technical experts, and IT skilled personnel. In the traditional system, HEIs require spending much time and money on having a highly skilled IT Department for the ICT infrastructure. Therefore, the benefits gained from adopting cloud computing technology includes mainly cost-effectiveness. Services offered by cloud technology have the potential to reduce total IT expenses and free HEIs from the cost of purchasing, implementing, and maintaining hardware and software locally [15]. In fact, HEIs can operate their IT systems effectively without having to spend large amounts of money on developing their IT infrastructure [14]. As a result, Cloud computing helps universities concentrate more on education and research activities rather than complex IT configuration and software systems [9].

3) Collaborative work: Most HEIs in the world are becoming extremely dependent on modern ICT in terms of fulfilling their service requirements for communications, and collaboration. Cloud services boost collaborative work which brings instructors and students to the same platform and improve relationships between them. Likewise, students team up with schoolmates on a variety of tasks without being in the same room.

4) Easy management: Cloud-based services provide for HEIs a multitude of choices in management. This enables easy upload and access to lesson plans, lab practical, student attendance, student grades, guides, lecture notes, assignments and much more study material at any point of time. In addition, this assists staff to perform various academic responsibilities according to their own requirements and enables them to focus more on their research and teaching goals.

5) Learning practices: Despite the role of cloud services in today's teaching and learning, little is still known about its application in the higher education context and in the opportunities involved. One of these applications is the implementation of creative and different methods of teaching and learning as alternatives to traditional classroom methods which are currently dominating the sector in many institutions. Besides, the need for the most effective methods and platforms of teaching and learning embraces the rapidly expanding cloud-based technologies. The role of cloud computing tools in promoting learning practices in higher education is provided by different services. We mention;

- learn without the time boundary for creative projects and practical assignments and enhance their effectiveness.
- store schoolwork and test-related materials and provide students with immediate feedback.
- incorporate critical thinking, problem solving, communication, and collaboration skills into traditional core knowledge instruction.

- promote students' interaction during the problem-solving activities, reflections, knowledge sharing, and idea generation [5].
- support competence development and provide instructors the appropriate training and support.
- promote continuous learning by enabling personalization, customization, and accessibility to guide students in the collaborative process.

B. Challenges

In addition to the promising advantages, cloud-based services include various issues and challenges that must be managed for a truly successful paradigm shift for the HEIs [16]. Indeed, the adoption of the cloud among universities has fluctuated over the years due to these different challenges. [16]. First, migrating existing legacy systems to the cloud is difficult and costly.Also, the risks leading to non-adoption range from security issues to a lack of cloud vendor support. The lack of control and ownership of data are considered as the major issues.There is also a risk for any institution to become "locked-in" to the products of a particular provider and may find it more difficult to migrate. In addition, there are some implementation challenges for HEIs such as improper management, integration, complexity, and affordability. Examples of this include lack of effective strategies for improving communication, coordination, balance of member contributions, and mutual support [2].

The lack of training and the low-technology competence also present an important barrier for faculty members, since it requires adjustments in the traditional teaching practices. Besides, [14] suggest that security, privacy, and trust are the key determinants of non-adoption as stakeholder.

Finally, for students, the lack of reliable Internet access where ideas can be incorporated and understood within and between group members is a common challenge for using cloud computing tools.

V. Proposed Cloud-based Environment for a HEI

We propose a cloud-based environment to realize the above-mentioned opportunities from both students and universities' perspective.

From students' perspective, we aim to familiarize students with all service models orchestrated together in a comprehensive cloud environment that provides the opportunity to deepen their knowledge and put into practice their expertise in several fields, such as system administration and development. Our strategy focuses on stimulating the students 'creativity and not considering them as simple consumers of services.

In addition, offering a high level of control in a cloud based-environment through the orchestration of different service models allows students to achieve important learning outcomes. According to Bloom's Taxonomy of Educational Objectives, there is a hierarchy of categories of cognitive skills, achieving analysis, evaluation and synthesis levels of knowledge. It requires manipulating and orchestrating a complete cloud environment that covers all service models offering the possibility of learning new skills and evaluating them.

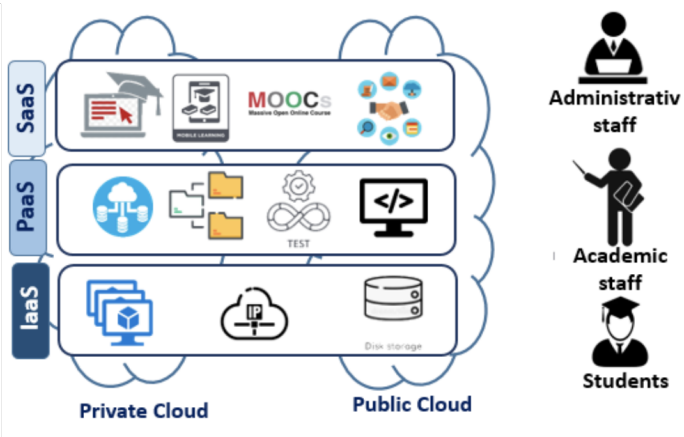

Fig. 1. Cloud-based environment architecture

From universities' perspective, they produce intellectual capital. All educational material that includes course specifications, course reports, course material, curriculum, student's projects, assignments etc. are considered intellectual capital for an institute. When this capital is shared with other educational institutes, instructors and students would benefit them and cause reduction in duplication of efforts. In addition to intellectual capital universities have their own data that they use internally to run business on a daily routine basis. This data, however, cannot be shared with other universities and it is called operational data [3] Handling these two types of data motivates the relevance of cloud-based environments that orchestrate deployment models in order to streamline operational efficiency and speed up development for universities. We demonstrate the architecture of our proposed environment in figure 1.

A. Application and Analysis of cloud-based environment in School of Engineering

The discussed School of Engineering is a private higher education institution founded in 2003, it employs around 500 people and hosts more than 8,000 students. The four core departments are Civil Engineering, Electromechanical Engineering, Information Technology, and Telecommunications. Many recognitions demonstrate the world-class pedagogy created by the school faculty and have contributed to strongly positioning Tunisia as an academic center of excellence for STEM education within the global research and innovation ecosystems. The school student-centered pedagogical approach enables students to assume greater responsibility in the learning process by being constantly engaged in role playing scenarios, team-based activities, and problem-based learning projects to solve complex problems, often derived from real-life settings. The school also provides several academic and non-academic facilities and services to students including administrative services. At this School of Engineering, we earnestly consider the inclusion of cloud computing in our IT strategy.

This case study of successful implementation is addressed to demonstrate the key opportunities associated with the use of cloud services at this School of Engineering which were presented and discussed.

We expose the architecture of the cloud-based environment,and how different university users may consume services. The main users of cloud computing are students, instructors, researchers, administrative staff, technical staff and the administration branch.

It encompasses three cloud service models and two cloud deployment models. For a typical university setting, each of these three models is useful as they all have their unique features relevant to the different university needs. The IaaS is the foundation of all other services, with PaaS and SaaS built upon it as shown in the architectural diagram. IaaS provides the infrastructure and the physical and logical connectivity between the hardware resources. PaaS provides a programming environment, middleware capabilities, and database to build applications on the cloud platform. The SaaS includes management capabilities and applications.

In this study, a hybrid cloud model is presented. The architecture consists of private Cloud and public Cloud. Hybrid cloud is the suitable model to be implemented because of its flexibility and blended characteristics between public and private models. By deploying the proposed model, this School of Engineering as a higher education institution in a developing country is able to:

- balance capital and operational expenses and can make optimal use of in-house resources while improving responsiveness to dynamic requirements,
- meet disparate needs and diverse workload requirements,
- shift certain workloads such as e-mail or collaboration sites to less-expensive public cloud environments,
- avoid the risks of data privacy as critical and sensitive data are housed in a private cloud.

It's important to mention that this cloud environment also played a very important role in quickly solving the problems faced by this School of Engineering during the pandemic of covid-19 .To cope with its effects, we had to rely on our workspace and learning management system to maintain the higher education activity. We had to move to remote education using Google Classroom (GC) and Moodle to ensure asynchronous and online synchronous learning. Mobile and e-learning were the key success factors for students and instructors during this phase. Staff skills were another strength to act quickly in order to design new learning activities and to exploit digital technologies to plan, prepare, teach and assess. In the design and delivery of these course materials there are many factors that are respected. We focused on providing a simple, intuitive, and flexible teaching system .Using this environment, instructors are being recorded and their content is being reused and are able to reach a larger audience. It also allows them to share instant feedback and grading and improves planning and management. In the following, we give a more detailed description of our architecture, technologies and deployed services and we show how some challenges described in section IV.B were overcome.

TABLE I
TECHNICAL SPECIFICATIONS OF THE DATA CENTER.

	HP Cloud Matrix Configuration	Extension
Compute	64 cores (Xeon E5-2650 8 cores each) 512 GB RAM	26 cores / CPU 512 GB RAM
Network	10 GB	10/20/25GB
Storage	64 TB	42 TB

1) Private Cloud: The private Cloud is providing basic computing resources including servers, storage, hardware, and networking equipment necessary to support educational, research and development activities. Private resources are shared within the school but also may be shared with other universities. To deploy a private cloud, it was necessary to understand the needs of the faculty, students, staff, administrative department, the exam department and the information system department within the institution. Before going for complete adoption of the cloud services, this school of engineering provided the necessary training, support and resources to implement and support this cloud-based strategy. Then, the services that need migration and the services that remain in the institute physical servers are decided. The most sensitive applications such as the admission process, accounting and financial services, and legacy systems such as human resources and the front-end web layer are running on premises in a private cloud. Our private Paas facilitates development and deployment of software using "Compass" which is a private solution, Red-hat Openshift and Kubernetes. Table I lists the performance characteristics and capabilities of HP Cloud Matrix deployed at the Data Center as an IaaS solution for private cloud deployment. This Infrastructure was extended to meet the scalability requirements. Compute, storage and network capabilities were expanded.

2) Public Cloud: Applications that require rapid scaling and the majority of online-based tasks are currently carried out by a public cloud such as email, collaboration, editing and writing documents and creating other online content. In our environment, the public SaaS combines the services of different providers to serve students and staff of the School of Engineering more efficiently. First of all, Google Apps for Education are adopted as one of the most used applications. At this School of Engineering, by implementing Google cloud services, we were able to cut costs in software licensing and maintenance of applications and in information security, while gaining the ability to access resources and share information anywhere and at any time. Furthermore, Google Apps as a collaborative and interactive platform fostered the competence development of students. Although, our school emphasizes learning through problem-solving, the aim of which is to "put students in real workplace situations". Then, the educational cloud initiative of Amazon is used to provide access to online training resources and labs to learn, practice, and evaluate

cloud skills. Finally, other solutions like Microsoft services (Office 365, Dynamics CRM, SharePoint), Github and SAP S/4HANA Service are accessed online through cloud technology.

The public PaaS layer provides access to different platforms and programming languages and makes it possible for programming students to easily develop and deploy their applications by simply connecting to the cloud. This layer is hosted on a public cloud using Microsoft Azure and IBM Bluemix.

On the other hand, the use of online learning activities has notably been supported by cloud computing. Using LMS offers varied forms of communication, collaboration, access to online materials, and track progress of the group work [1].

Moodle and Google Classroom are widely adopted by educational institutions as LMS to enable administration and management of learning contents, communication, assessment, and collaboration.

Moodle is an open source e-learning application that enables students to share and collaborate in a varied task condition. Its application within higher education comes in different forms, for example, it can be operated along with mobile cloud-based learning 'Teamwork as a Service or TaaS' to maximize the benefits students receive when collaborating in teams of certain capabilities and preferences [17]. Moodle was used for its flexibility and open-source nature. Nevertheless, it has been mainly used as a local learning repository with underutilized adaptation of its interactive learning tools. In view of the above, we looked for another LMS to be cost-effective, easily accessible, and user-friendly.

One of the most rapidly adopted online learning platforms for anyone with a Google account is GC [18]. In fact, the use of google email systems at this School of Engineering was effective for the adoption of Google Classroom. Moreover, GC is designed to promote learnability [19] through providing quick and easy access to learning contents, secure cloud storage, collaboration, management, and communication platform that support small to large course participation [20].

By using Google classroom, the School of Engineering enables instructors to provide 21st century learners, who live in a media saturated environment, to design online tasks and to define a well-organized instruction. Furthermore, what made Google classroom rapidly adopted as an online learning platform is its interactive and collaborative features that support face-to-face teaching, in addition to the use of other Google applications such as Google Docs, Drive Sheets, Gmail, and YouTube. Moreover, students found Google meet useful and easy to use which promoted their engagement and satisfaction.

These applications facilitate exchange between students and instructors of any higher education institution in developing countries. They are accessed from anywhere via tablets, computers or mobile devices.

Figure 2 illustrates how cloud computing is used in the School of Engineering and exposes different services and technologies.

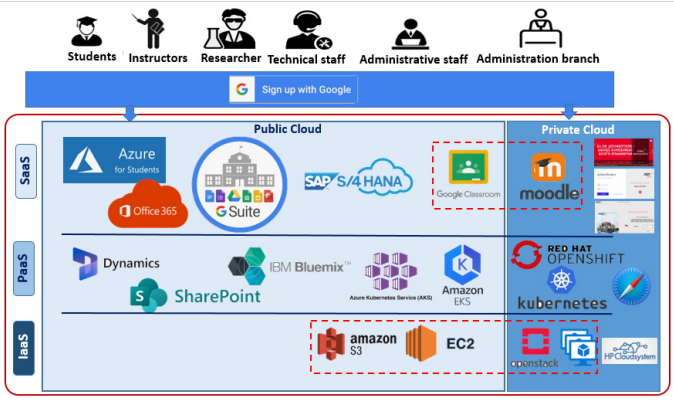

Fig. 2. Cloud-based environment in School of Engineering

VI. Survey for Environment Validation

We propose a questionnaire survey to validate the proposed environment and determine the real impact of our environment in higher educational institutions (HEIs) particularly engineering education in developing countries.

The purpose of this study is to examine the experience and view of the School of Engineering with regard to the implementation of the proposed cloud-based environment in their courses.

We aimed to explore the perception and opportunities involved in using Cloud tools mainly from the students and instructors' perspective. We conducted both a questionnaire and an interview as means of primary data collection.

This questionnaire survey was conducted as a study to investigate the way students experienced our environment in a remote learning environment. The respondents aged between 19 and 22 years are enrolled for an engineering curriculum who have a socio-scientific background. Our questionnaire is composed mainly of five questions. These questions are as the following:

- **Q1**: Did the proposed environment help to facilitate communication and collaboration with colleagues and instructors?
- **Q2**: Did the proposed environment allow to acquire simply more skills?
- **Q3**: Did the proposed environment help to improve the teaching process?
- **Q4**: Did the proposed environment be able to use and master new technological tools?
- **Q5**: Did the proposed environment help to innovate in productions and achievements?

These questions aim to validate the added value of our proposed environment mainly;

- Facilitating the communication and interaction between students and instructors.
- Improving the acquisition of new skills and knowledge.
- Putting into practice expertise in several field and deepening the knowledge of both students and instructors.

TABLE II
SURVEY RESULTS

	Disagree	No opinion	Agree	Completely agree
Q1	60	138	211	224
Q2	94	119	255	165
Q3	76	102	253	202
Q4	79	167	257	130
Q5	82	127	267	157

- Supporting innovation by providing the required services in an orchestrated environment.

We managed to collect 633 responses from our students presented in Table II.

The analysis of these results is discussed in the next section.

VII. Findings and Analysis of Results

In this part, the data obtained from the survey applied to our students are evaluated. In light of the research questions, we explored the respondents' experience with using the proposed cloud environment. We analyze the answers of our students from different angles.

First, we consider the Collaboration Technology Experience (CTE) Indicator which is defined as the degree of knowledge and experience that a user has acquired in using collaboration technology in order to improve communication. In this study, we aim to evaluate the impact of the proposed environment on communication and collaboration between students and instructors. We estimate this indicator based on the results of question 1 (Q1). The results of this question (Q1), as illustrated in figure 3, confirmed that the highest percentages are distributed, respectively over 33% of the interviewed students agree and 38% completely agree that the use of the cloud-based environment has a great impact on facilitating communication and interaction between students, therefore ensuring a fast and efficient share of knowledge.

Second, we consider the Performance Expectancy (PE) which is the positive expectation indicator of the students about the enhancement of their performance when utilizing a new technology. PE has been considered as one of the strongest indicators of intention to use new technology [21] . This indicator is considered and presented in our study precisely in questions 2 and 4 (Q2 and Q4). The results of these questions (Q2 and Q4) as illustrated in figure 3, confirmed that 40% of the interviewed students agree and 21,5% completely agree that the use of our environment enhanced their performance and improved their collaborative learning outcomes.

Then, we consider the Self-Efficacy (SE) indicator which is explained as students' belief in their abilities to achieve desirable types of performance [22] . Students with advanced SE perceptions can tackle their problems independently and set higher commitments to the goals. In this respect, students consider new technologies to be less difficult to learn and use, and they are likely to exert more effort to overcome challenges. Therefore, the teaching process is significantly enhanced. This indicator is considered in our study in question

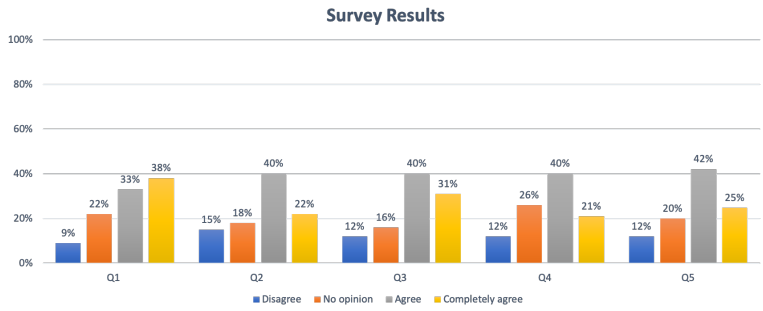

Fig. 3. Cloud-based environment

TABLE III
QUALITATIVE COMPARISON AFTER ADOPTING THE PROPOSED CLOUD-BASED ENVIRONMENT

Before Cloud-based environment	After Cloud-based environment
Information asymmetry	Rich learning environment
Fixed time and location	Access resources and knowledge in different locations
Rigid software solutions	New Services
Traditional communication and collaboration	Better collaboration
Traditional exams and tests	Customized assessment environment

3. The results of this question (Q3), as illustrated in figure 3, confirmed that 40% of the interviewed students agree and 31% completely agree that using several cloud services orchestrated together covering different disciplines and fields allowed them to modernize their way of dealing with the learning process. Moreover, integrating cloud-based services leads to support of advanced learning processes.

Finally, according to [21], Facilitating Conditions (FC) is the level to which a user feels that needed infrastructure is provided to simplify the innovation usage. In this study, FC is considered to be the students' expectation about the accessibility of all the technical and organizational support to use in the cloud-based environment in order to innovate and propose new solutions. This indicator is considered in our study through question 5. The results of this question (Q5), as illustrated in figure 3, confirmed that 42% of the interviewed students agree and 25% completely agreed that the use of the proposed environment helps to innovate in production and achievements.

We also conducted an interview with 15 instructors, to qualitatively assess the adoption of the proposed environment. Concerning experience, all these instructors had experience using GC, the same background in teaching education technology, and were aged between 30 and 35 years. To sum up their feedback, we present a qualitative comparison in table III to illustrate the states before and after adopting our proposed cloud-based environment.

VIII. Conclusion

Despite the intensive use of cloud computing, limited research has been conducted regarding the use of environments

based on cloud computing by HEIs in developing countries. This research focuses on the adoption of cloud computing in HEIs. Models, opportunities and challenges of using cloud technologies in the process of learning are considered. In this paper, we confirmed earlier studies that highlight the role of clouds in HEI. It also adds new insights on adoption opportunities of cloud in institutions in developing countries. In fact, we have exposed the Cloud architecture of a school of engineering that combines both the current local infrastructure as the private cloud and public cloud to enable the sharing of educational resources and collaboration. We demonstrated how Cloud Computing is applied. A study which focuses on students and instructors' experience in using Cloud in higher education particularly in teaching engineering was conducted. We found that the cloud-based environment is very effective in supporting collaborative and cooperative activities and in facilitating teaching and learning of IT engineers.

It is suggested that future research focuses on how to integrate artificial intelligence to our cloud based environment to offer an adaptive learning context and enhance discussed indicators.

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