OPEN LEARNING SKY: A CONCEPTUAL FRAMEWORK FOR A CLOUD BASED OPEN eLEARNING ENVIRONMENT

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ABSTRACT
The technology revolution has its strong impacts on different fields and industries. E-learning is one of those fields that is dramatically affected and changed over the previous years. Cloud computing and Web 2.0 features (i.e. blogs, Wikis, etc.) provide great opportunities to move e-learning to a new era. Different initiatives are established based on employing the cloud and Web 2.0 capabilities. This paper highlights the limitations of the contemporary initiatives. The paper introduces a framework for an open learning environment called Open Learning Sky. The aim of the proposed learning environment is to provide learning in more open, flexible, adaptive and interactive format.

KEY WORDS
Cloud computing, open e-learning, e-learning architecture, education.

1. Introduction
E-learning is one of the most actively researched fields in information technology. Due to the continuous technology revolution, it is changing and evolving dramatically. It is changed from being fixed, isolated process to be more flexible, interactive and convenient process. The revolution of mobile services and communication technology contribute to emerge a new form of e-learning, which is m-learning. M-learning refers to learning through mobile devices. It is considered a part of e-learning [1]. Over the recent years, various technologies have been applied in order to improve and support e-learning and m-learning. Some of those technologies are Service-oriented Grid [2-5], intelligent agents [6, 7] and Deep-web technology [8]. Recently, most of the research focus on applying cloud computing to e-learning, as it is considered a great opportunity for educational institutions to achieve different benefits.

The recent emerging of cloud computing and the capabilities of Web 2.0 technology lead to move e-learning to more open and flexible format. Recently, different initiatives that aim to provide learning materials in freely open format are established or announced [9-16]. Every initiative has its own features that make it distinct and its own limitation as well. Reviewing all the contemporary initiatives and studying the capabilities of cloud computing and the opportunities that it can offer to e-learning domain, led the authors to propose an open learning environment, which is called Open Learning Sky. The aim of Open Learning Sky is to provide learning to the world in an open, flexible, adaptive and interactive approach. The aim of this paper is to introduce a preliminary design of the proposed Open Learning Sky. This design is based on cloud computing technology and involves different tools and techniques that support adaptive and interactive features.

This paper is organised as follow. Firstly, section 2 provides a background of some related concepts which includes cloud computing and its relation to e-learning as well as an overview of the concept of open learning. Next, section 3 presents some of the defined limitations of the current open learning initiatives. Then, the proposed design of Open Learning Sky is presented in section 4. Finally, the paper is concluded in section 5.

2. Background

2.1 Cloud Computing
Cloud computing is a new era of computing technology. It is classified in [17] as the fifth generation of computing after mainframe, personal computer, client-server computing and the Web. Cloud computing moves the computing infrastructure and data away from the users to the cloud, and provides them on-demand as a service over the Internet. Five essential characteristics are defend by The National Institute of Standard and Technology (NIST) for cloud computing. These characteristics are on-demand self-service, broad network access, resource pooling, rapid elasticity and measured service. In addition, NIST defines Cloud Computing as follows: “Cloud computing is a model for enabling 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”[18].

Cloud computing has four different deployment models [18-21]. The first type of these deployment models is the Private cloud, which refers to the situation when the cloud is owned solely by a specific organization and not available to the public. It can be managed by the
organization itself or a third party and it can be either on-premise or off-premise. The second type of cloud deployment models is the Community cloud. It refers to a sharable cloud infrastructure that is supported and used by a community of consumers from different organizations that share the same concerns. The cloud can be hosted and managed by a third party or one of the organizations in the community. Public cloud is the third deployment model and currently it represents the most dominant model of cloud computing. It refers to the situation where the cloud is owned by a single owner organization, which has its own policy, costing and charging model. Consumers are charged for services consumed, which makes computing availability similar to any other consumable services. Currently, different public cloud providers exist providing varying services - e.g. Amazon, Google, Microsoft and others. Finally, Hybrid cloud which is a composition of two or more different clouds (private, community or public) that remain separate entities, but are bound together by standardized or proprietary technology to enable data and application portability. Hybrid cloud raises the issues of cloud standardization and interoperability [19].

Another classification of cloud computing is based on the services provided. Different models are defined in the literature and they are as follow:

- **Software as a Service (SaaS).** In this kind of model, hosted applications in the cloud are provided to be accessed and used by consumers via a network. These applications are broad network access, which means that they can be accessed by any clients' platform [18].
- **Platform as a Service (PaaS).** This model offers to consumers a development platform that allows them to develop applications using programming languages, libraries and other tools are supported by the cloud provider [18].
- **Infrastructure as a Service (IaaS).** In this kind of cloud models, computing infrastructure (e.g. processing, storage, networks, etc.) are provided to consumers, in which they can deploy software including applications or operating systems [18].

### 2.2 Issues and Opportunities of Applying Cloud Computing to E-learning

Cloud computing provides many opportunities to be applied in teaching/learning environments. Different benefits of applying the cloud in e-learning systems have been mentioned in literature. These benefits affect both learning providers and learners. Firstly, using the cloud technologies can financially affect the learning institutions, as the cost of constructing educational information systems can be reduced by adopting the cloud [22]. In addition, providing educational software as a service contributes to reducing the software licensing cost for educational organizations [20, 23-25]. Furthermore, shifting the responsibility of some computing maintenance to external providers contributes to cutting the cost of labor, as less IT staff will be required [26].

In addition to the financial benefit, using cloud providers gives the opportunity for educational institutions to provide better services to their students, as cloud providers take away the IT-related maintenance overhead from the organizations. This provides an opportunity for the local IT team to focus on requirements that provide better support for learners (rather than IT maintenance issues), which positively affects the overall learning process [23].

Using cloud technology allows learning institutions to provide their students with a 24/7 access to virtual labs that have all the required tools to accomplish learning goals. All that is required is a device with an Internet browser which makes learning a really flexible process [20, 22]. In addition, using the cloud provides a permanent, flexibly accessed repository for students, which allows their data to be kept safe and always backed-up [27, 28].

Furthermore, cloud computing is able to provide better learning resource management. It provides enhanced management mechanism, automated deployment and high level virtualization, which all contributes to better integration and utilization of learning resources [22, 24]. In addition, it is stated that resources and course contents can be evolved collaboratively over the cloud and shared, which leads to highly efficient, up-to-date resources [20, 29].

Finally, in terms of m-learning, using the cloud leads to enriching and supporting the usage and application of mobile learning. One of the major deficiencies of mobile devices is the limited local memory and storage capacity. Using the cloud certainly contributes to overcome this shortage, as data is stored remotely and can be accessed over the Internet. So with cloud technology, learning materials can be hosted remotely and learners are able to access them flexibly anywhere and anytime. In addition, the unlimited storage capacity that is provided by the cloud technology supports the use of multimedia learning contents in m-learning [30]. It offers a great opportunity to construct a mobile educational resource library that is able to be accessed in a flexible approach [31, 32].

Despite the benefits that educational institutions can achieve by adopting the cloud, there are many concerns that still limit achieving their full potential in teaching/learning environments. These concerns are raised from the challenges that still face cloud computing, and they are related to some major policy issues including data privacy, security, availability, reliability, telecommunication and bandwidth capacity, and government surveillance [25, 27]. Storing data in remote datacentres raises different concerns of data loss and privacy. Government surveillance in some countries where datacentres are hosted may give the right for the government to access the data in some circumstances without even informing the data owner. Service availability and reliability is another concern when using cloud technology. Service Level Agreements should be
defined clearly between cloud service providers and consumers in order to cover most of the consumer’s expectations.

Although data security is considered as one of the major concerns, it is believed by Pocatilu et al. in [33] that using the cloud provides some significant security benefits for educational institutions. In cloud environments the real location of data is undetermined [33]. In addition, Pocatilu et al. have different views regarding data loss in the cloud paradigm. They believe that, using the cloud and storing data in a remote datacentre reduces the possibilities of data loss that might happen in other computing paradigms. This is because cloud service providers are responsible for data back-up and maintenance, and the service providing agreement should guarantee that to the cloud clients.

2.3 Open E-learning

The capabilities of today’s technologies support the transformation of e-learning process. E-learning can be more learner-centred than how it is used to be. Learning materials can be provided over the Internet and learners are able to access them whenever they want. In addition, such an approach allows learners to control their learning progress and going forward in courses based on their abilities and gained knowledge.

Over the few recent years a number of initiatives of using cloud technologies in e-learning have been established by different parties. Some of these parties are prestigious educational institutions, such as Stanford and MIT and others are private organizations, which provide a collection of courses that are provided by different learning providers. These initiatives provide learning in an open flexible way. Every learning provider has its own goal for applying such an attempt, and its own approaches for providing learning materials. In addition, analyzing the various available initiatives shows that there are some similarities and differences between them in terms of different criteria. Adaption, assessments, accreditations, support, payments are all managed differently by the different providers. More details about these similarities and differences are presented in [34]. Some of the current prominent open learning initiatives are Khan Academy [9], Stanford Engineering Everywhere [10] and Stanford on iTunes U [11], Coursera [12], Udacity [13], LearningSpace [14], MITx [15], and finally edX, which has been announced lately and will be started in September of 2012 [16].

The concept of open learning is shown to be successful and as effective as the traditional face-to-face approach in terms of the student progress and learning. A study that is presented in [35] examined the concept of open learning on students who are doing a statistics course in Carnegie Mellon University. The effectiveness of open learning courses is evaluated on three different learning models: stand-alone, instructional and hybrid. The study is done by offering the course materials online, and it is found that this approach does not affect the learners’ progress comparing to the progress of the traditional learners. Moreover, it can accelerate the learning process to the half of the assigned duration. Another study of evaluating the effectiveness of open learning is presented in [36]. It is based on publishing the course materials on YouTube. The process is found to be successful and considered to be a good approach of moving the learning process from a private, closed form to an open, accessible form. It is also considered a helpful approach in enhancing teachers’ abilities as they can benefit from the experience of others.

3. Limitations of Contemporary Open Learning Initiatives

Despite the various open learning initiatives that are held around, each of those initiatives has some limitations that do not make it the perfect model of the future. The goal of e-learning is to provide a flexible way of learning that makes the learning process more convenient and achievable. Excluding edX and Udacity, no other open learning providers are providing an accreditation or qualification for the learners. However, edX and Udacity lack the flexibility factor that makes learning more convenient, as learners have to commence the course in a specific date to be able to access all the assessment components. Moreover, most of the contemporary initiatives are based on offering learning materials without paying consideration to the variations between different learners in terms of knowledge or progress. In most cases learning are held in such a linear fashion, which does not consider the variety of knowledge in such a large, anonymous audience of learners. So, evolving the course design methods in such a way which considers those aspects will be helpful in making such an open learning paradigm the future of learning. Finally, assessment approaches and authentications methods are also other components that are worth to be evolved in order to ameliorate and enhance such a paradigm.

4. The Proposed Framework for Open Learning Sky

Based on the previous defined limitations of the contemporary open e-learning initiatives, this paper aims to present a proposed design of an open e-learning framework. The design of this framework is based on the concept of presenting learning in such an open, adaptive, flexible platform. Learning materials will integrate from different learning providers and provided to the interested learners from all over the world. Such an aim can be achieved by using the cloud architecture, as the cloud concept allows the integration of different services from different providers to form a virtual environment that is capable to serve enormous number of users (i.e. learners).
4.1 Novel Elements of Proposed Framework

- Providing open, flexible tertiary learning materials that are not restricted by time constraint for the commencement and other assessment commitments.
- Providing adaptive learning materials, so that learners get access to materials that suit their knowledge and cognitive level.
- Building knowledge maps to define programs and different learning topics. Based on the authors’ knowledge, this approach is only applied by Khan Academy for math materials [9].
- Integration of different providers at different levels. For example, multiple providers will provide virtual labs infrastructure at different levels of service. In addition, learning materials will be developed collaboratively by multiple learning institutions/individuals.

4.2 The Main Components of Open Learning Sky

The proposed framework will consist of three main components. These components are learning providers, cloud service providers and learners. An illustration of these components is presented in (Fig.1) and a description of each is given below:

1. Learning Providers: learning providers can be divided to two main groups, learning institutions and learning resources publishers. The first group, learning institutions, is represented in tertiary education providers (i.e. universities), which will provide different courses to be accessed through the open cloud. The second group is represented in the learning resources publishers, which are responsible of providing the required resources to support the learning process (i.e. e-books, slides, etc.). Learning materials will be provided in different formats, such as lecture videos, lecture slides, e-books, etc. These materials can be accessed by anyone for free. Organizing partnership between universities and publishers is essential for providing learning resources in the open cloud. In addition, E-assessments will also be provided, which will be one of the major components of the adaptability model.

2. Cloud Service Providers: services in Open Learning Sky can be provided by public or private service providers. Public provided services can be used for hosting learning resources. In addition, virtual labs that offer fully equipped workstations for learners can also be hosted on the public provided infrastructure. These workstations can be shared between learners who belong to different courses from different universities, which leads to better resource utilization and management. On the other hand, private cloud can be used to store data that are private and sensitive, such as assessment items and learners record.

3. Learners: learning through the Open Learning Sky is available with no restriction to any interested learners. Learners can learn different topics from different universities based on their interest. Learners can join different learning communities that spread widely all over the world and they will have access to different facilities that support their learning process.

4.3 The Main Features of Open Learning Sky

The proposed framework for Open Learning Sky has some features that support the potential goal of it. The goal of Open Learning Sky is to provide learning in an open, flexible, adaptable and affordable style. Following

![Figure 1: The different main components of the open learning sky](image)
is a description of the designed features:

1. **Accessibility**: Open Learning Sky is a cloud based framework, which makes it broad access, thin client platform. Learners can access the learning resources easily and flexibly. All the required to access the learning materials is a device with an Internet browser. In addition, learners are able to learn anywhere and anytime using any device with limited features, such as tablets, smart phones or even public PCs.

2. **Open education**: Open Learning Sky is a cloud based framework, which provides learning in an open form over the Internet. This allows learners in rural areas with limited technical capabilities to access learning resources, and communicate with learning communities. In addition, it gives learners the opportunity to learn with a very low cost comparing with the traditional way of learning.

3. **Adaptability**: Learning Open Sky will be a dynamic adaptive platform, which means that adaptive properties are identified by learners’ interaction with the environment. Learners’ preferred learning style (i.e. textual, visual, audio) can be identified by tracking the learners’ activity. Consequently, a set of related learning materials with the preferred learning style can be suggested. In addition, learners will be able to define their learning objective, so that they can get a list of topics and learning resources that lead them to the desired objective. The learning path to the defined objective will be in an adaptive format, so that learners do not have to learn in a traditional linear format. They learn and are guided to learning materials based on their abilities. Learning topics will be divided into different sub-topics and organized in a knowledge map format. Every node in the knowledge map will be associated to a set of assessments. If learner shows certain knowledge in specific topic then he/she can move directly to advance topics.

4.4 The Architecture of Open Learning Sky

The proposed architecture for the open learning sky consists of four main layers. Every layer has a set of functions that support the features of the desired open platform. An illustration of these different layers is presented in (Fig. 2), and following is a list of them with a description of each.

1. **Application layer**: this layer represents the web portal that open learning sky will be accessed through. This web portal is compatible with various platforms and can be accessed by different devices.

2. **Access layer**: this layer is responsible for some of the significant functions of this system. Firstly, it determines the way of presenting the learning materials to the learners based on the device and the platform that is used. In addition, this layer is also responsible for managing the adaptability feature of the Open Learning Sky, so that every learner will get access to the learning materials in such a way that suits his preferences, needs, knowledge and ability.

3. **Integration layer**: The function of this layer is to integrate the different components of the open learning sky and providing them in a unified platform. These components include the various tools that support the process of providing the learning

![Figure 2: The architecture of open learning sky](image)

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materials, interaction, assessments, etc. In addition, this layer plays a mediator role between the infrastructure layer and the other components of the system.

4. **Infrastructure layer:** This layer represents the entire physical infrastructure of the system. These infrastructures can be provided by public cloud service providers, such as Google, Microsoft, etc., or by private cloud providers (i.e. the learning institutions which are part of the open sky community). Services that are provided by private providers can be used to manage some sensitive data, such as assessment items, students’ records, etc.

5. **Conclusion**

E-learning is one of the fields that are changing and evolving continuously. E-learning is meant to be a flexible and convenient process that allows learners to learn whenever and wherever it suits them. Recently, e-learning started to take this approach, as some initiatives have been established by different parties to provide learning in a freely, open form.

Based on the review of the contemporary open learning initiatives and the study of the cloud computing capabilities, a design of a cloud based open learning environment is proposed. This paper introduces a preliminary design of the proposed environment, which is called Open Learning Sky. The main components of the proposed framework are presented along with its main features. In addition, a high level description of the proposed architecture is provided.

6. **Ongoing and Future Work**

The presented proposed framework is part of an ongoing collaborative research project. So, as part of this research the framework will be implemented and evaluated. Some online materials will be hosted in the environment, so that the efficiency and functionalities of the proposed framework can be evaluated. In addition, the impacts of such a learning approach on the learning process and learners’ progress will be evaluated as well. Moreover, learners’ satisfactions will be measured by holding surveys.

Recent updates on the conceptual realization include the following main point of progress in the research:

1. Configuration and installation of a Moodle [37] environment for prototype development.
2. Preliminary course module materials for cloud hosting. This module is designed in a knowledge map format, so that the proposed adaptability functions can be applied and evaluated.

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