# Ubiquitous Classroom Enhanced by a Cloud-based Server

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Abstract: The development of cloud computing technology, smart digital devices and ubiquitous computing systems, bring many new opportunities for the area of education. Indeed, smart classrooms support the use of these various technologies to enhance new ways of learning, teaching and assessment. This paper presents a novel architecture of a ubiquitous classroom enhanced by a cloud-based server. The designed smart classroom makes devices such as smart boards, projectors, printers, etc… connected through a gateway in order to encourage active interactions between learners and teachers. By considering the benefits of cloud computing in this field, we improved this model of classroom by implementing a cloud-based server that provides an efficient remote control of the classroom devices through this gateway. This system facilitates the access to learning data and educational applications for students using their smart devices. In this paper, we provided an overview of the enhanced ubiquitous classroom based on cloud, its characteristics and finally we reported some important scenarios offered by this model.

## 1 INTRODUCTION

Technologies have been used, to develop innovation and changing in education, and to enhance the quality of interaction between learners and teachers through the implementation of smart classrooms which are intelligent classrooms equipped with many digital devices that can be reconfigured automatically and can detect for example the arrival of students; store the discussion of the lecture through laptops, tablets, etc.

In fact, collaborative learning is based on groups of students working together to search for understanding, and to share experiences. The achievement of this evolution in educational environment requires the establishment of smart spaces which are connected through different smart devices. Thus, the advent of new technologies such as cloud computing and pervasive computing…has completely changed the concept of teaching that provides an accomplished teacher-student communication.

Classically, learning methods help students to reach their goals by applying many approaches to learning that encourage and motivate them to learn. Therefore, an important number of concepts based on using a wide variety of models in educational technology such as e-learning or distance learning, which is a teaching system implemented to be remotely accessed via electronic communication. The evolution of e-learning to other concepts for instance m-learning and b-learning becomes very interesting these recent years (Martin and Gil, 2008).

Mobile learning or m-learning (Klassen and Elan, 2013) is the use of handheld devices to facilitate access to training courses. Blended learning or b-learning (Chao and JingDong, 2008) is the combination of traditional classroom and e-learning, this merge online with habitual face to face activities. Hybrid education or b-learning uses online technologies to develop the teaching process. Eventually, the next evolution of learning and development is called s-learning (Martin and Gil, 2008) that keeps the theory of using various educational objects to make re-usable instructional and advanced services to be readily incorporated in Learning Management System (LMS).

However, in novel methods of learning systems, students can interact within the smart classroom with their own devices, such as tablets, mobile phones or PCs. In addition, learners are already familiar with the device that they are working with. So, the advantages of using these personal resources are many such as prepare practical labs or presentations, working on assignments, writing their observations or personal expression, etc. The last few years, many


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students reported that using personal computer in educational courses is better than writing with pencil and notebooks for the reason that they might perfectly review courses or labs at home, they could modify their work in order to help them to take advantage of the portability of learning content. Moreover, this concept, offers the opportunity for teachers to interact with their students, to further improve courses taught and the quality of lecture through the achievement of practical labs for example which still available to learners during the reviewing.

Hence, the potential benefit is the use of various equipments in ubiquitous classroom environment that enables real-time interactions and communication to transmit digital educational content. Therefore, teachers can receive instantly the lecture feedback and the questions asked by students via these smart devices. This new cooperative approach to teaching in the field of education makes reciprocally beneficial learning innovation for both students and educators. On the other hand, the main advantage that teachers can more perfectly remote their classrooms through monitoring personal devices of learners working in groups. Definitely, the authors are aware of the benefits of combining technologies and collaborative learning.

The main goal of this paper is to propose a new architecture of ubiquitous classroom enhanced by a cloud-based server. The designed smart classroom makes all devices such as laptops, projectors, etc connected through a gateway in order to allow students to be more involved in collaborative learning and to encourage active interactions among learners and educators. Firstly, the cloud-based server provides an efficient platform for the remote control of the classroom devices through the gateway. Secondly, students and teachers who are connected to this improved server can access to learning data and educational applications using their various devices.

The rest of this paper is outlined as follows. In section II and III, we briefly describe the technology-enhanced classroom and then we present some previous work. After that, we illustrate the architecture and the design of our proposed system (cloud-based classroom) in section IV. Finally, we conclude in section V with summary and future work.

# 2 TECHNOLOGY-ENHANCED CLASSROOM

Technologies in the field of education are required in today's scalable learning environment. Smart classrooms are a novel way that offers a high quality of teaching to students by facilitating them the improved training of concepts, enhancement in communication skills and educational success.

Technology-enhanced classrooms are equipped with audiovisual and electronic materials, smart interactive whiteboards, data projectors, virtual labs tools and computers, etc enabling educators to benefit from a diversity of media while teaching. Smart classroom is a current project at ESPRIT that completely changes the method of "teachers" who typically teach and "learners" who learn without reflecting. These classrooms provide the use of several technologies through the connection of various devices in order to transform the learning experience for students who have improved their academic achievement at the university. Besides, educators are able to use their own intelligent tests in classroom through the system and employ them for assessment. In addition, learners are using a variety of devices such as tablets, mobile phones, personal laptops to answer questions that replace actually the pencil and the notebook. At home, the use of these personal equipments as handheld remote or PCs allows them to review their notes and assignments anywhere.

Smart classrooms provide also the possibility to share smart resources, connected to the classroom, with several other locations. This concept is supported by e-learning approach that brings new opportunities for the way of education and provides a high quality of the distributed information. This method is offered to students, who have a prevention to attend physically the lecture. The smart spaces are implemented with embedded computers, information devices, and multiple sensors that permit students to follow the lecture and achieve assignments by offering the possibility to remotely access the IT system and computers. It provides operational interfaces which allow the instructors to approve a new teaching experience by implementing hardware and software technologies to control students' devices through displaying information at their screens.

Over time, many educational researchers have developed novel methodologies for the pedagogical process; the most revolutionary method is known as online learning or distance learning which offers an efficient platform to achieve the same learning

outcomes without the requirement of using the face to face communication in the same place. Hopeful students, have successfully spent towards a new world of education which proves the concept saying "each learner is able, at any place and any time access to a classroom equipped with multimedia materials"…instantly the student is liberated to a world of information that responds to all constraints of the pace of learning. Rather, based on this approach there is a lot of researchers and learners think about migration to the area of virtualization.

The system of virtual classrooms is accessible at any moment unrestrictedly. This enables students to approve a rich and new learning experience. The rate of data transmission is relating to the user's speed connection because it is an instant communication from the platform and the remote device used by student. In addition, educators can dynamically control the teaching process as they do in traditional classroom; they interact with the real time feedback, and provide a more sophisticated way of assessment activities remotely.

However, there are multiple methods which can be used in order to implement a performing system of virtual classroom. This platform requires the establishment of many particular equipment at both sides the institution and learner. So, students must have an extensive knowledge of operating systems, networks and several tools used to provide remote access. This type of classroom can be equipped with a server that is configured with learners' accounts and other devices must be implemented to accomplish this remote interaction such as video and audio systems, interactive whiteboard, etc.

All technologies used currently in classrooms leads us to ask the main question: Is there any way to replace or to enhance smart classroom?

Obviously, ubiquitous learning is the most appropriate answer because this kind of technologies has an important impact on education. It is defined as learning anytime, anywhere using several devices. The use of pervasive or ubiquitous devices and mobile technologies in educational environment such as smart phones, PCs, iPods, and other equipments as interactive whiteboards which use numerous network connections include Wi-Fi or Bluetooth, and NFC, provides an enhanced way of learning to the students who receive the personalized information.

The concept of u-learning (Joung-Souk, 2009) illustrates the use of ubiquitous computing, that offers an interesting mode of linking mobile devices. These equipments and tiny sensors facilitate the interaction with educational environment and allow the exchange of data among students and teachers.

Let's be deeper in the explanation of u-learning. Typically, ubiquitous learning is a novel learning environment which is available through a variety of contexts. In fact, ubiquitous learning complies with many characteristics such as the accessibility that offer to students the remote access to their data or videos from any place. The second criterion is the interactivity that allows the two-way communication between learners and educators in real time. Thus, teachers have feedback instantly and the knowledge becomes more accessible. In addition, the permanency is very important in this context since the students cannot lose their data, labs or work, all the learning information or processes are saved daily within the system.

U-learning is a particular category of distance education which is based on the use of various devices and technologies to encourage collaboration through delivering comments, tips and instant feedback even for students who attend distance training. U-learning is known by its increased capacity of moving physically the learning environment anywhere. Hence, the main goal of any type of learning is to overcome the constraints of human everyday life and especially to improve the quality of teaching, to achieve these objectives already mentioned; so it is necessary to implement new architectures using ubiquitous technologies and specific tools.

It's obvious that cloud computing represent a significant change in the field of education as ubiquitous computing. The cloud provides the remote access data at any moment, and any place. It changes the way of communication, learning, and working in classroom. Thus, it's necessary to use several resources such as memory, data storage, and the rate of bandwidth which will be shared among distant learners.

## 3 RELATED WORK

This section presents some works which focuses on presenting previous models of technologies used in the context of smart classrooms. The main issue of the existing work is smart classroom using ubiquitous computing, web service technology, cloud computing and management of online courses classroom devices, in order to facilitate collaborative learning.

There are many projects treating the progress of traditional education with a wide variety of technologies such as pervasive computing. These

researches cover several concepts of smart learning activities. Thus, the problems of the ancient type of education are numerous as the fact that students cannot attend the course or the practical sessions and write their observations, or results simultaneously. So, through the use of cloud and pervasive technology and the software solutions, teachers and students can exchange comments and observations through the screens of different devices connected to the system.

The paper (Bargaoui and Bdiwi, 2014) presents a designed gateway for ubiquitous classroom. It enables teacher and students to have interactional classroom where several devices are connecting through this gateway. In (Shri and Subha, 2013) E-learning application in private cloud (Cluster based Environment) is developed using several technologies. The paper demonstrates a cloud computing architecture system that provides persistent storage, scalability, and remote access, of the E-learning system objects.

The researchers in this paper (Catherine and Christos, 2012) explore the use of pervasive computing devices in the higher educational environment. A study on characteristics and applications of the future ubiquitous computing devices is illustrated.

The progress of ubiquitous learning environment offers the combination of the benefits of an intelligent learning environment, the advantages of ubiquitous computing technology and finally the usage of various mobile devices. The system of learning between student and teacher is not restricted to e-learning. There is an implementation of system (Joung-Souk, 2009) that allows learners to be supported with a way of authentication, an electronic input, distribution, gathering, and support learning multicast.

The main goal of this work (Di Lecce and Taranto Giove, 2009) is to present the concept of the implementation of a collaborative learning interface based tool for virtual classroom; it is used in order to analyze the users' data to assess the rate of participation of students in the e-learning system proposed.

Other researchers have designed in (Kong and Ogata, 2009) a type of smart classroom that provides integration among a system of e-learning based on web and simply classroom based e-learning that offers the reporting system which connect numerous modalities of communication.

The paper (Premchaiswadi and Tungkasthan, 2010) describes an overview of e-learning system known as an interactive virtual classroom which use a sophisticated protocol based on TCP real time networking called RTMP (Real-Time Messaging Protocol). It provides the synchronization of many types of data and facilitates the interaction between teachers and learners who can directly exchange messages as in a real classroom through using a web-based collaborative work.

A different system using cloud computing technology (Wang and Hu, 2013) is implemented to demonstrate how the future classroom can use multiple services based on the technology of cloud computing in order to ensure smart control, a very high capacity of data storage level, the secure management, which can be shared among many devices. In (Dinita and Wilson, 2012) a cloud based solution for learning in educational environment is illustrated. This system use virtual infrastructures based on various equipments such as switches, routers and virtual PCs that explain many virtual scenarios of communication among educators and students.



# 4 CLOUD-BASED CLASSROOM

## 4.1 Ubiquitous Classroom

The ubiquitous classroom is a new classroom model that contains multiple smart devices such as printers, projectors, smart board. These devices which are connected via a gateway acts automatically when detecting learners.

This system provides a real-time communication of information offered by the intelligent educational environment, allowing the teacher and students to have an interactive classroom. In addition, the gateway manages the devices in the classroom and serves as a platform for executing educative applications that provides services to improve the course. It allows for example the verification of student's attendance in a very simple way, when they enter the classroom. The architecture of the ubiquitous classroom is described by Figure 1.

This ubiquitous classroom has two major components. The first component is the smart devices and sensors. The students and the teacher can interact with these several devices such as smart board, computer, interactive response system, video and audio devices.

The second component is the embedded gateway, which enables the exchange of data with smart devices. It contains a middleware that provides the ability to run many educative applications and add support for new devices.

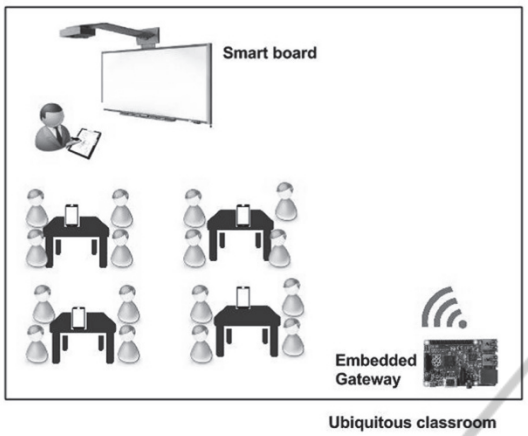


Figure 1: Architecture of ubiquitous classroom.

Figure 2 shows the software architecture of the gateway. It consists of four layers: the layer of access technologies, device manager, class manager and the application layer.

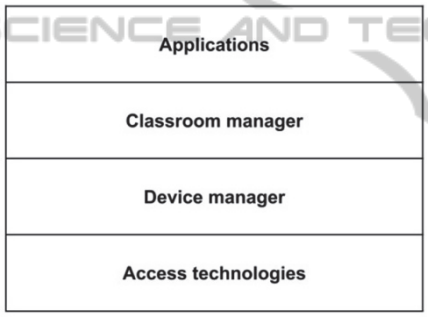


Figure 2: Middleware architecture of the gateway.

The Application layer contains the services deployed in the classroom. The second layer is the classroom manager which provides an adaptive behaviour based on the course profile. It permits also the communication between devices. The device manager layer role is to detect the currently available devices, to provide a standard access to devices through a common interface. Finally the physical access layer is in charge of connectivity over access technologies such as Bluetooth, Wi-Fi, USB, etc.

## 4.2 Cloud-based Server for Enhanced Ubiquitous Classroom

The cloud-based classroom server contains a platform of e-learning, administrative tools and database server. Its main objectives are distance learning, user management, and finally remote management of multiple classrooms. The e-learning platform is accessible from different client devices through a thin client interface such as a web browser. The designed ubiquitous classroom enhanced by a cloud-based server is described by Figure 3.

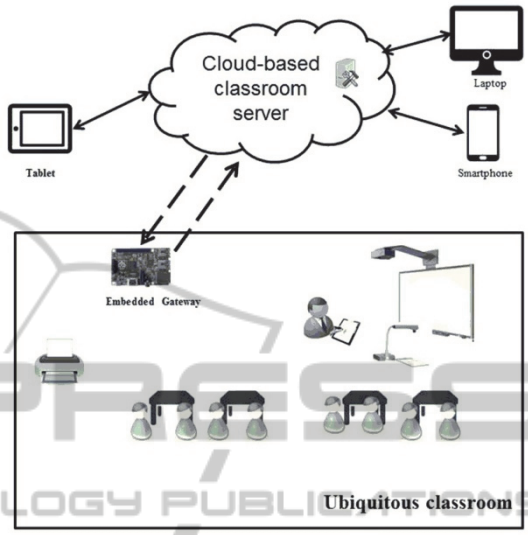


Figure 2: Architecture of ubiquitous classroom enhanced by a cloud-based server.

Using the architecture presented above, learners and teachers can connect to the server, which provides at the same time distance learning and course loading on smart board in the classroom. Further, it provides a sophisticated assessment system and the remote management of classroom's embedded gateways. Indeed, it can handle multiple classrooms because each classroom has a profile on the server.

## 4.3 Implementation

For the implementation of our proposed solution, we have chosen the Raspberry-Pi board and the OSGi framework for the designed gateway. Thus, various smart devices used throughout the system are respectively RFID reader and smart video projector controlled by an Arduino board. The main benefit of Raspberry-Pi is that it combines the characteristics of a single-board computer and has the size of a credit card.

Let's explain why we used OSGi. It represents a service platform and an efficient modular system for the Java programming language which serves during the implementation phase as a dynamic and complete component mode. Therefore, the educational applications can be remotely installed, uninstalled, started or stopped, and finally updated without restarting. The Arduino is also known as

single-board microcontroller dedicated to facilitate the access to applications, interactive objects or smart environments. Finally, RFID (Radio Frequency Identification) is a set of technologies used to identify persons and different objects wirelessly.

In addition, an e-learning platform such as Moodle will be deployed on the cloud server with the integration of different modules in order to manage the profiling system which control several classrooms.

### 4.4 Applications Scenarios

In this part, we conducted two scenarios to validate the ubiquitous classroom enhanced by a cloud-based server.

The first scenario is about practical lab. This is an example that can demonstrate the seamless interaction among teachers and students with classroom devices, and a cloud server. Students who walk into the classroom have just their NFC tags near the RFID reader to indicate their presence. This information is transmitted instantly to the cloud server via the gateway. Then, the application located in the gateway will load from the cloud server the teacher profile, the appropriate course and the list of students. When the teacher enters into the classroom an identification device based on RFID system will detect his presence. Through the use of the cloud server, the course will be loaded automatically into the smart board depending on the already loaded class profile. The document of the practical lab will also be printed via the printer according to the number of present students. The assessment of student work will be achieved on the cloud server through laptops or tablets.

The second scenario treats the assessment process as for language exams. So, the subject of the exam will be loaded from the cloud server and projected to students on the smart board. Learners using their tablets, laptops... are connected to the e-learning platform on the cloud server. They can view the problem situation on the board and interact with the online assessment system by answering questions simultaneously. In this way, teachers can perform the online evaluation of the student responses. Through this system, we described the changing of the assessment method of student learning that can improve the quality of teaching, and it provides to the educators the possibility to have an immediate feedback on the student learning outcomes.

## 5 CONCLUSIONS

In this paper, we designed a ubiquitous classroom enhanced by a Cloud-based server. It combines at the same time the features provided by ubiquitous classroom and virtual learning environment deployed in a cloud server. Indeed, we explored the benefits of cloud computing which can serve in educational environment to overcome several limitations of ubiquitous learning.

We are currently implementing the proposed system which illustrates an ecosystem for both virtual and ubiquitous classroom due to a very thorough study which required a comparison among the process of learning using our architecture and the traditional educational environment.

The current presented design is still in progress as a lot of open issues that have to be considered. As part of our future work, the system needs the evaluation phase that already complements the implementation process in order to find out its advantages and restrictions. Further, this phase will demonstrate how our novel system can completely enhance the performance of learners.

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