The integration of augmented reality in the virtual learning environment for practical activities

Hamada El Kabtane, Youssef Mourdi, Mohamed El adnani, Mohamed Sadgal
University Cadi Ayyad, Marrakech, Morocco
hamada.elkabtane@ced.uca.ma, youssef.mourdi@edu.uca.ma, {sadgal, md-eladnani}@uca.ma

***Abstract*— E-learning systems suffer from a lack of tools to provide practical activities for learners. The mixed reality is promised to be a new technology to create a virtual environment where the learner is an actor by interaction with virtual objects. The objective is to establish a virtual laboratory that all tools and products can be manipulated by learners like in real practical work. This virtualization can also solve the safety problems and may reduce the risk of some experiments: nuclear, chemical, etc. Another interesting benefit is the reduction of the investment on real hardware (locally or remotely). We propose an approach for developing integrated E-learning systems, helping to carry out the practical work by the distance learner based on an augmented reality system.**

***Keywords:* E-learning, virtual reality, augmented reality, practical activities.**

I. Introduction

The emergence of E-learning has opened a wide window for solving several problems such as availability of media, collaboration and group work at different geographic positions without the need to travel ... But in some domains, we must have access to the physical material or useful products for a good training and a good assistance to qualified users. This kind of training and evaluation is expensive and does not evolve well, and it is out of learners' reach. In activities such as practical work, some authors [1] proposed "tele-TP" as a solution that involves making a distance manipulation by remote control real instruments and synchronous telemetry. It also requires a real hardware to achieve the desired goal. The tools of mixed reality (virtual and augmented reality) allow users to set up a learning or evaluation environment and then interact with the educational environment.

Many tools have been proposed as a technological breakthrough that has the power to facilitate learning. Research and Application of Mixed Reality technology (MR) in education have enriched the form of teaching and learning in the current strategy in education. This constitutes the Virtual Learning Environment (VLE), which not only provides rich teaching models and learning content, but also helps improve the ability of students to analyze problems and explore new concepts.

With the VLE, learning content has become interactive and the learner can make a self-evolution during his studies, allowing him to follow his progress in the E-learning in a simple, sophisticated and precise way. The teacher, in turn, can follow each learner and controls his level since the platform. The VLE allows performing experiments that are up to now expensive and sometimes impossible in the real world [2].

We propose in this paper an architecture integrating virtual learning environments in e-learning systems. The model uses the Augmented Reality (AR) techniques to present a complete course with practical aspect. The realization of such a system aspires to the completion of some activities in a virtual way like the practical work in distance learning courses or in high-risk environments (experiments in the presence of chemical products,...) and it can economize on tools [3].

The rest of the paper is organized as follows: In the first section we present the state of the art starting with the adaptive architecture of E-learning systems, and the "Mixed Reality" with its benefits. The second section will describe the proposal. Then in the third section we outline the architecture of the proposal and a description of its components. In the fourth section we will present the implementation. Ultimately we conclude in the fifth section.

II. State of the art

A. Adaptative E-learning:

The use of the information technology in e-learning systems is very profitable [4] [5] because it offers a wide knowledge base in an area that the learner can operate freely. The need for automation has produced the Intelligent Tutoring Systems (ITS) that offer the integration of intelligent tutoring systems to guide the learner closely in his learning process [6] and limit its lack of focus, by [7]. ITS and micro-worlds systems consist to subtract the knowledge from farms and experiences not from the induction of knowledge, they allow to integrate adaptation in educational facilities provided by Educational Computer-Aided (ECA) systems. There is three types of learners: auditory learners, they are a good listeners, they prefer to hear, to talk of what they learn, and also there is the visual learners, they like to use pictures and videos to understand what they learn and they use colors, graphics and schemas to take notes and finally the third type the kinesthetic learners, they tend to have the possibility to move, do experiments, go on excursions to live the experience, to examine and to manipulate the material. The implementation of systems such as AHSE "Adaptive Hypermedia System Education" [8] allowed calling reflexes learner using a collaborative training [9]. This system aims to adapt to the individual needs of each learner [10], and his level of knowledge [11], interests [12], preferences, stereotypes [13], cognitive preferences [14] and learning style [15] [16].

The architecture of this system, according to [17] can be simplified to a learner model, a content model that contains a set of elements of domain knowledge studied [18] and an adaptation strategy (Figure 1).

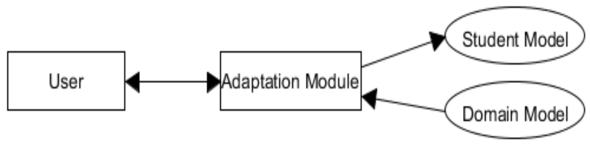

Fig. 1. Architecture of an adaptive educational system

The communication between the learner and the material to be learned is through platforms that enable knowledge management, information dissemination and include monitoring tools to check the progress of the learner. Among these many platforms, is the famous "Moodle" is a Learning Environment provides easy and inexpensive access to learning content and flexibility of time management [19]. Other platforms (DeleOs) try to incorporate other features like video-conferencing, etc.…. However, several problems arise: first motivation is rarely present and boredom sets. Moreover, the creation of quiz is limited which makes the tracking of evolution very long.

It therefore becomes necessary to guide the development of these systems with the introduction of so-called MOOCs (Massive Open Online Courses). These are E-learning platforms adaptive represent a new trend in higher education, often based on knowledge sharing video.

The MOOCs are of two types according to [20]: the xMOOC (Coursera or edX) which consist in transmitting an existing knowledge and the cMOOC which rely on the generation of knowledge by learners.

B. *E-learning and Practical Works(PW)*

Many extensive research has shown that students benefit from e-learning [21] and [22], some of those benefits are that it economize in cost and time for educational institutions specifically in the fields of practical activities, because if learners can determine what to construct or create, they are more likely to engage in learning [23], in this area the practical works in the E-learning solves many problems like the availability of material and the space where the learner can realize the experience, also the practical works in the E-learning solve the big problem of safety of the learners against the dangers they may come from experiments (nuclear, chemical, etc.).

To resolve the problem of the practical work integration in E-learning, some solutions proposed like the use of video; Videos allows students to view actual objects and realistic scenes, to see sequences in motion, and to listen to narration, in most e-learning systems that use videos, learners cannot skip part of the video to a particular part that consume a lot of time because the learner forced to view and listen to the full video until the part he wants, but the major problem with the use of instructional video has been lack of interactivity [24], the video remains static whose the learner can no longer interact with.

Also some works inspired from LICEF (cognitive informatics laboratory and training environments at the University of Quebec) model allow remote handling by the remote real instruments and synchronous telemetry, with feedback by channel audio - video – computer; however we don't use simulation or simulation software for PW. Certainly, this model offers an intermediate educational support between academic and reality, but causes additional costs: environmental networks, the system of remote controls ...) and the learners are just observers they watch the unwinding of the practical activity through the platform, as it is depicted in Figure 2, the model of the solution shows how the tele-pw system works.

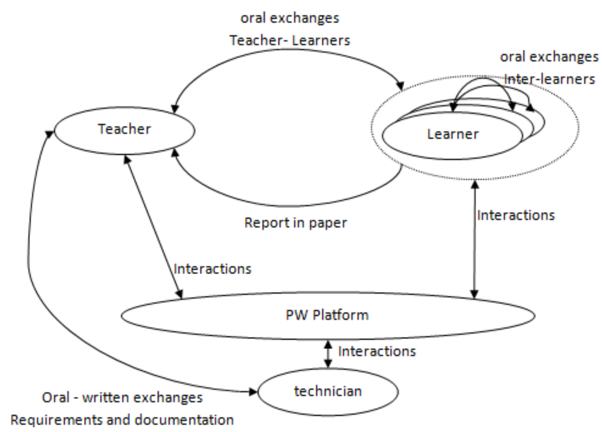

Fig. 2. Trade in a classic PW

C. *Mixed Reality (MR) and the Virtual Learning Environment (VLE)*

Virtual Reality (VR) is the use of computer graphics systems in combination with various display devices and interface to provide the effect of immersion in the interactive 3D environment generated by computer [25]. We call such environment, a Virtual Environment (VE).

Applications of research and development in VE can be found in many places around the world.

A system of Augmented Reality (AR) is a combination of the real world with a virtual environment to enrich the original phenomenon with information so that they seem to coexist in the same space [26]. There are three characteristics that must be integrated into an AR interface: the combination of the real and the virtual, the feasibility in three dimensions and real time interaction. The AR technologies, unlike those of Virtual Reality (VR) are not intended substitution of the real world with a virtual analogy. The foundations of AR lies essentially in the aspiration to create an "intuitive" interfaces and easy to use [27]. All studies are trying to go beyond the usability of AR interfaces problems and test the effectiveness of systems for learning and cognitive processes.

Mixed Reality (MR) refers to the incorporation of virtual computer graphics objects into a real scene in three dimensions, or the inclusion of elements of the real world in a virtual environment. The first case is usually referred to as augmented reality, and the second as augmented Virtuality.

Milgram [28] proposed a continuum of Virtuality, with the real environment at one end and the virtual environment to another. Augmented Reality (AR) and Augmented Virtuality (AV) are located between the two (Figure 3).

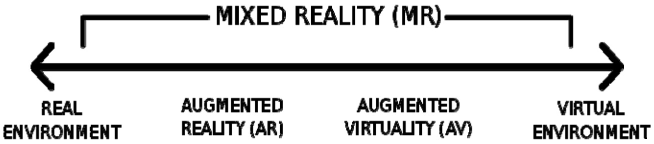

Fig. 3. Virtuality continuum (Milgram [20])

The Virtual Learning Environment (VLE) not only provides rich templates and various teaching learning content, but also helps improve the ability to analyze problems and explore new concepts of the learner. Integrated with immersive benefits, interactive and "imaginational" he built a shareable virtual learning space that can be accessed by all types of learners involved in the virtual community.

The VLE can help learners to make a cooperative study, and make the necessary interactions among them. During an experiment, the interaction can provide various controls to the learner, such as interaction with the virtual environment and handling of characters or objects in the virtual environment.

The VLE technologies can meet a wide range of interaction capabilities. For example, Maes [29] built a video based interaction with artificial agents called Alive System. [30] focuses on virtual collaborative learning environment on the Web. It provides a cognitive architecture based learning constructivism.

III. Proposal

For the kinesthetic learners, distance practical activities (i.e. Practical Work PW) represent a crucial part of distance education that has been poorly addressed in current scientific research. However, this type of education is essential in scientific and technical disciplines and responds to a real need heavy and expensive industrial facilities can't be moved or be duplicated.

To cope with this vacuum, the distance PW or "tele-TP" or classic presential PW was appeared. It's a traditional form of teaching practice which was eventually changed, but also extended to be accessed remotely via networks (i.e. Internet).

Recently through virtual environments, Virtual Reality (VR) offers a lot of possibilities to realize behavioral interface for users with a virtual world. In these immersive environments where the user is represented as a model (avatar), it can be equipped with a motion tracking that allows to know the position, orientation ... of more parts of body. According to these models, the user can perform a command using different types of devices that are associated with a large number of variables.

In virtual worlds learners can control there avatars through keyboard, mouse or joystick. They interact and use the virtual objects, created and loaded by the teachers and technicians, to realize there practical activities. (Figure 4)

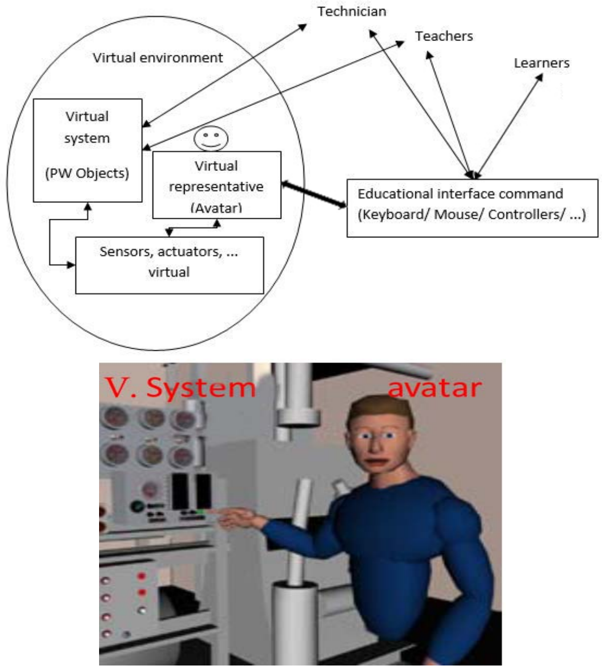

Fig. 4. Schema in VLE manipulation through a representative (AVATAR)

Despite the success of these implementations, some difficulties remain and lie in the activity interpretation which must rely on formalizing of description models. The design, use and operation of these models require the collaboration between computer scientists and educationalists.

We propose to integrate the AR into VLE enabling users to interact with the system and manipulate directly PW objects as in the real world without intermediaries (joysticks, mouse....). Thus, during a practice session, the learner interacts with virtual objects in order to achieve the required experience and can avoid risks during the experiments (explosion, electric shock...) in the real world.

A. The AR system:

This system has a virtual reality module producing a virtual world (figure 5a), a module for detecting objects in a video (real world) and operations to integrate them in one world with the possibility of interaction between all objects (real and virtual) (figure 5b).

What we propose is to adapt practical sessions to the user and to implement its provisions virtual interactive means. Instead of just watching the progress of PW on a video (no interactivity) or using remote commands (pseudo-interactivity / "Tele-TP"), our solution combines virtual reality, where objects are created by computer graphics with their functional aspects (virtual objects), and the augmented reality that allows the user to directly manipulate the virtual objects.

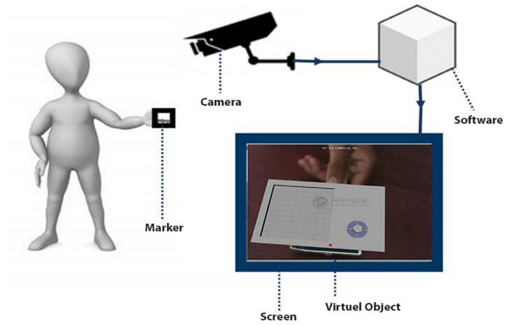

Fig. 5a. Example of the Augmented Reality module

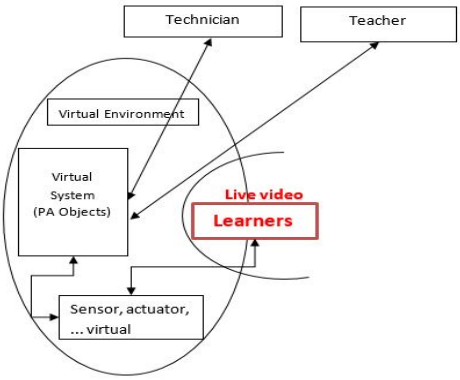

Fig. 5b. Proposed system: Schema in VLE manipulation by direct interaction in live video

B. *The general architecture of the solution*

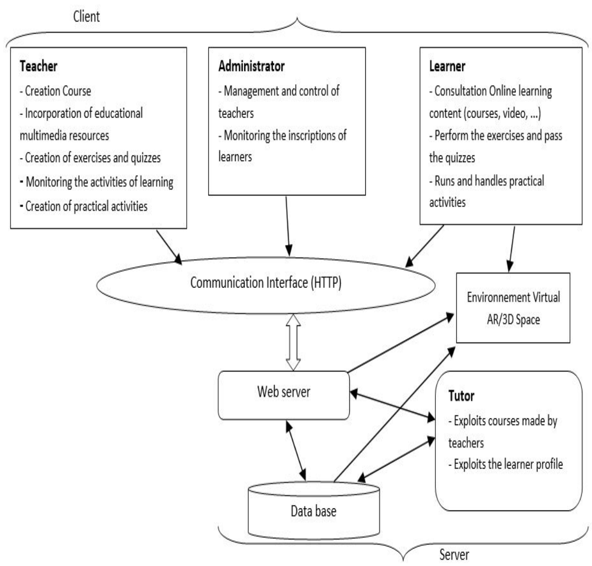

Fig. 6. Schematic of the global e-learning platform

In the E-learning platform, we have 3 actors at the client level: teachers who are mainly responsible for content platforms, they add courses, exercises, quizzes and Pw and more than that they can track the status of progress of their learners. There is also the 2nd actor: learners can access online distance courses, perform the exercises, quizzes and pass the handle practical activities. The 3rd actor: administrators whose role is the control and management of other actors (teachers and students).

The intermediary between the platform and the actors is a web interface that queries the web server which in turn communicates with the database and intelligent tutor who ensures the adaptation of educational content to learners. (Figure 6)

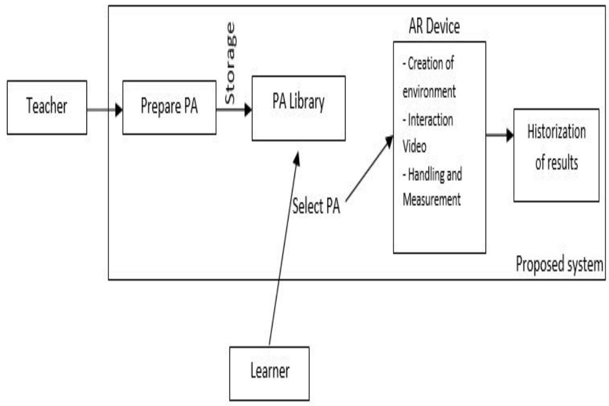

Fig. 7. Schematic of global practical activities in E-learning platform

In the E-learning platform, the professor creates and poses a course, prepares a practical activity and stocks it in the library of the practical activities of the platform, and after that the learner reads the course and makes the exercises and passes to practical activity. After choosing the PW by the learner, our system performs the creation of environmental performance of the activity and generates the necessary tools for successful experience using video interaction and allows the manipulation of objects to the learner and when he finishes practical activity, the system switches to the archiving of reports created by the learner to leave a trail to the teacher to monitor its progress (Figure 7).

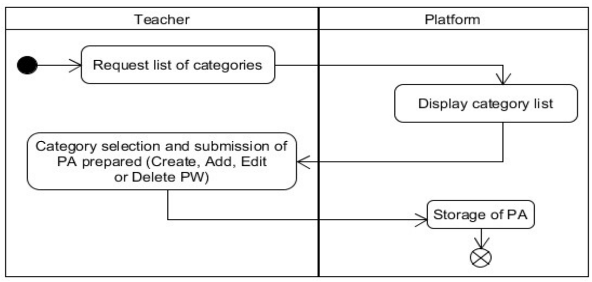

Fig. 8a. Activity diagram of the teacher's part

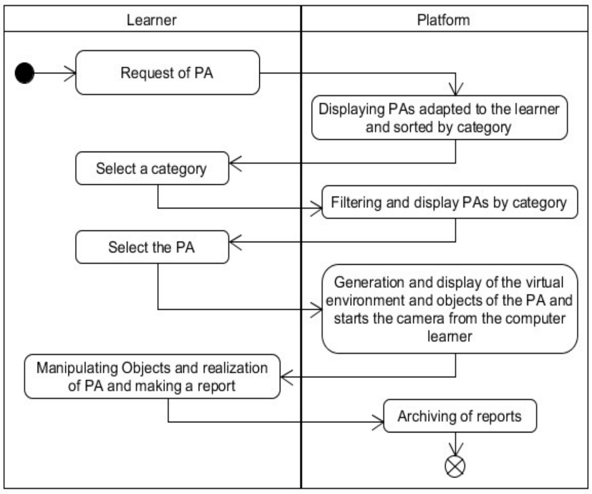

Fig. 8b. Activity diagram of the learner's part

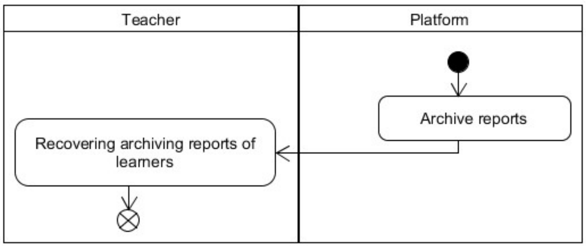

Fig. 8c. Activity diagram of the 3rd part, the request of archiving reports

The teacher can create, add, edit or delete a Practical Activity and he can request for the list of categories in the platform. He chooses the category of the PW prepared and store the PW in the platform. (Figure 8a)

In the learner's practical activity part of the E-learning platform, the learner finds an archive of practical activities where exists all PW destined and adapted to his level. Once found the desired PW, the selection system isolates the PW and contacts the generation system objects and environment to provide the necessary items to perform the experiment. (Figure 8b)

After PW is displayed on the screen when the learner finishes the realization of the PW, the platform proceeds to archiving of reports realized by the learner, which the teacher may consult later. (Figure 8c)

Description of components

- Archive PW: It's a library containing all practical works classified by categories (electronics, chemistry, physics...), as well as descriptions and methods of realization of those practical works.

- Selection System of PW: This system is responsible for adaptation and sort practical works existing in the archive according to the needs and interests of the learner. The learner, for example, in the first year, learning the engineering sciences and specially electronics, then the system eliminates all the practical activities that are not useful for him and just displays those of first year electronics.

- Generating system objects: Based on the selected by the learner and its adaptation by the selection system works, the system selects 3D objects needed to generate the virtual lab environment displayed on the display screen.

IV. Implementation

The practical works are created as animated scene in 3ds Max, which is a 3D modeling software, it offers a complete solution for modeling, animation, simulation and rendering for game designers and film, as well as computer graphics [31]. The PWs created take place in Opensim [32], which is an open source multi-platform, multi-user 3D application server. It can be used to create a virtual environment (or world) which can be accessed through a variety of clients, on multiple protocols. The teacher can use it as a scene to create the PW (figure 9), he can import the 3D objects created in 3ds Max and put them in the scene, after that the learner finds all the objects needed to practice the PW (figure 10).

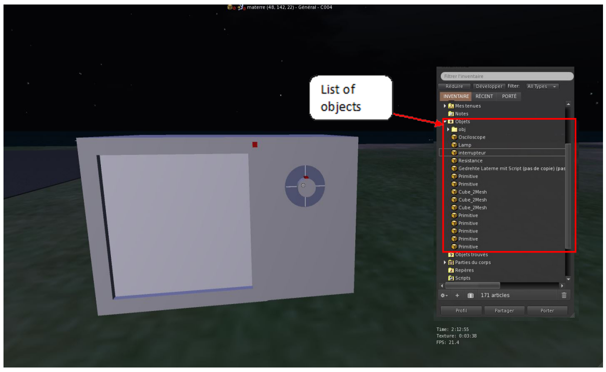

Fig. 9. Example object insertion by the teacher in Opensim

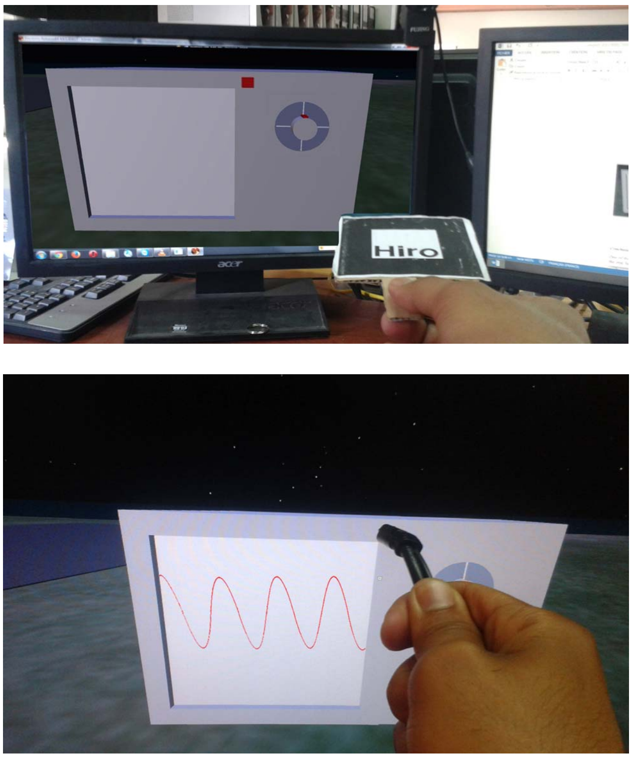

Fig. 10. Example interaction between the learner and the objects

V. CONCLUSION

One of the limitations of e-learning is the problem of doing practical work remotely without access to the real hardware as in [33]. We propose in this paper a model that contains all the elements and components of virtual construction which reduces the risks of overload and failure of materials, and most importantly, the learner just needs a single computer and a webcam.

By introducing the AR, the learner can interact with objects like in the real world. Because skills are completed by experiences and practices, the system based on our model leads environment and tools to help learners to acquire the ability by "doing".

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