

TOWARD AN OCCLUDED AUGMENTED REALITY FRAMEWORK IN E-LEARNING PLATFORMS FOR PRACTICAL ACTIVITIES

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Abstract

With the evolution of the internet and related technologies, a wide range of innovative solutions are introduced in order to solve different problems in several fields. One of the most prominent innovations is the E-learning platforms. These platforms allow the instructor to manage and control the learning content that the end user is going to consume. In many domains, the learner needs to have access to laboratory materiel and to manipulate some equipment in order to complete the theoretical background built in the course. Moreover, the use of videos, virtual laboratories or distance control of real equipment, to solve the existence of the practical activities in the E-learning platforms, is limited in occurrence and results. The Augmented Reality and the Augmented-Virtuality are the new technologies that promise to create a virtual environment, which gives the learner a virtual experiment space where s/he can experiment safely and with total control. In this paper, the authors propose a solution to carry out the practical activities in some E-leaning platforms whereby the learner can manipulate the virtual experiment elements like in real world: freely and safely without any risks. A survey was given to a sample of students, an instructor and a designer after a practical activity simulation, in order to get their feedbacks and to evaluate the proposed solution.

Keywords: E-learning; Virtual learning environment; Mixed reality; Virtual reality; Augmented reality; Practical activities.

1. Introduction

No one can deny that the rise of the internet gives birth to new ways to teach and learn things easily; it also allows the learners to study anytime and anywhere. It is called distance learning or E-learning. This last reflects the use of new information and communication technologies for knowledge sharing.

Abbreviations

AHS	Adaptive Hypermedia Systems
AR	Augmented Reality
VR	Virtual Reality
BVL	Biorefinery Virtual Laboratory
CVE	Collaborative VE-system
mDVE	Multi-user distributed virtual environment
MR	Mixed Reality
OS3D	OpenSpace3D
VCL	Virtual Chemistry Laboratory
VE	Virtual Environments
VLE	Virtual Learning Environment

In fact, the occurrence of the Virtual Learning Environment (VLE) not only provides rich teaching models and learning content, but also helps improve the students' ability to analyse problems and explore new concepts [1]. The Joint Information Systems Committee Managed Learning Environment Steering Group has said that VLEs refer to 'the components in which learners and tutors participate in "online" interactions of various kinds, including online learning' [2]. However, the VLE provides an interactive learning content whereby the learner can make self-evaluation during her/his studies and be given a sophisticated, precise and simple way to know about one's progress, whereas the instructor can easily control and monitor her/his learners' progression by simple clicks on the platform. Still, not all the E-learning platforms are VLEs; some platforms provide a different approach to ensure communication or to deliver learning content; like using E-mail.

There is no doubt that the implementation of practical activities in learning paves the way for learners to get familiar with the instruments and ultimately real world materials. Despite all, the e-learning platforms still suffer from lots of deficiencies, especially in the practical activity part, where the learners need materials and useful products for a good training to keep learners' creativity and motivation, especially in the engineering or the medicine domain. In addition, The learners' creativity must be improved and fostered by six different facets [3]: starting by 'Learning by doing', 'Curiosity and motivation', 'Independent learning', 'Self-reflective learning', 'Reach for original ideas' and finally 'Multi-perspective thinking'. The study in [4] indicates that especially the first, the third and the fifth facets might be fostered insufficiently in learning. Wherefore, the instructors in schools, middle Schools, high Schools and universities use laboratories to offer to learners the opportunity to implement their own experiments and build their experiences. Thus, the access to those laboratories is not always allowed to them, due to the availability of the experiment environment, the safety of the learners against the dangers caused by the experiments (nuclear, chemical, etc.), the limitation of the resources; unavailability, inaccessibility and the costliness of the equipment.

In order to go beyond the constraint of location, many tools have been proposed as a technological innovation which has the power to introduce practical activities in e-learning: Using videos, virtual laboratories and distance control of real equipment are solutions to integrate practical activities.

Mixed reality (MR) presents the fusion of computer-generated 3D objects with a real world scene to generate a new environment where the user can interact with in real time. On the Reality-Virtuality continuum proposed by Milgram [5], the real environment is presented on one end and the virtual environment on the other end. The Augmented Reality (AR) and Augmented Virtuality (AV) are placed in between depending on which one has been modified. The researchers admit that the AR and the AV, as an improved user interface technologies, will allow to offer several advantages in terms of increased teaching and learning environments, due to the progress that these technologies have known in recent years [6]. Those technologies are very beneficial in e-learning, because they offer a stimulation and motivation for learners to explore objects from different angles, they improve collaboration between learners, instructors and the supervisors, and they strengthen the learners' imagination. Also those technologies help to assimilate subjects that are dangerous or hard to teach (e.g. chemical, nuclear, astronomy, etc.).

Herein, we propose a solution that integrates practical activities based on Augmented Reality in some e-learning platforms like: Moodle, which is a famous e-learning platform and eMouss@ide, which is a self-correcting adaptive learning system that offers learning scenarios based on the learners' learning styles and has the ability to self-correct relying on traces and learners' feedback.

The rest of the paper is organized as follows: the second section presents a state of the art; adaptive E-learning, Virtual Learning Environment (VLE) and some actual systems for practical activities in E-learning. The third section describes the proposal. The fourth part outlines the results and the feedback of learners, instructors and designer. Ultimately, the fifth section is dedicated to the conclusion.

2. Literature Review

2.1. Adaptive E-learning

An e-learning system is defined as a platform that enables for users (instructors and learners) to reach several learning tools, like content repositories, assessments, discussion and document sharing system without limitation in time and place [7].

In the recent years, several solutions appeared in the context of distance learning. The majority of those solutions are based on the availability of high-quality educational resources [8], often detriment on the learners focus.

Huge number of studies proves that the learning is eased if the teaching strategies are consistent with the learners' learning styles. This compatibility makes the learning process improves the learners performances [9]. There are four main learning styles: some students prefer speeches and listening (A: Aural), others may understand quickly through texts, reading and writing (R: Read/write), some may learn easily from videos, pictures, graphs and schemas (V: Visual) and others may deal with experiments, excursions, manipulating objects and materials (K: kinaesthetic).

The internet contains a large volume of information that are not all credible, which leads the learner to a knowledge overlapping and exposes the learner to bad references [10]. So, the organization of the learning content is attached to many solutions like the Adaptive Hypermedia Systems (AHS) [11], that ensure the adaptation for the learners in the e-learning system especially if there is no assistance from a physical tutor (the instructor) who ensures the organization and

the adaptation of the learning content in the classroom. The AHS gives the possibility to consult the hyperspace smartly by adapting the content and the interface to each user of the e-learning platform [12]. The hypermedia system is adapted according to the user's knowledge, experience, knowledge background, preferences and her/his intentions [13].

There are many adaptive educational hypermedia systems developed since [14] such as InterBook, AHA, INSPIRE, ADAPTAPlan, etc. [15]. These systems are based on a general architecture that can be simplified to a learner model, a content model and an adaptation strategy [16].

2.2. Virtual Learning Environment

Virtual Environments (VEs) provide a way to combine the features of real-world information navigation with the features of the online navigation [17]. Several types of VE exist that can be used in E-learning:

- Multi-user distributed virtual environments (mDVEs): offer the opportunity to the users that are separated geographically to interact and communicate in real time [18] and give a shared sense of space, presence and time.
- Collaborative VE-systems (CVEs): an extension of a Multi-user distributed virtual environments which is intended for collaborative tasks.
- Virtual Learning environments (VLEs): An extension of CVEs intended not only for collaborative tasks but also for educational tasks. It refers to a system where the information can be presented in several forms, from text to 3D immersive worlds. It gives the opportunity to the learners to be actors in the system, and so they can create and co-construct the virtual space.

The VLE contains several tools that help the administrators to manage the learners and the instructors. In addition, it provides the required tools to instructors and learners to perform their tasks. The learners can pass the exams at a specific time and the answers are stored so the instructors can evaluate and correct them.

2.3. Actual systems for practical activities in E-learning

Practical activities encourage and enable students to be more engaged and attract their interest and attention, as well as enhancing several skills and giving insight into scientific methods and develop expertise in using them.

To implement practical activities in E-learning systems, several researches have been done, some of them have used videos to fill the existent shortfall in e-learning platform, where the experimentation was filmed and learners have to see the sequences in motion and to listen to the narration. The major limit in this solution is the absence of interactivity, the learner remains passive and can't interact with the objects [19].

Another solution has been proposed, the use of remote labs or a distance control of real equipment such as PeTEX project [20] and "Tele-TP" [21]. This solution gives the opportunity to the learners, without being present physically in the laboratory, to do experimentation and use the real equipment of the laboratory. An installed camera offers a video stream that allows the learner to track the experimentation. By using the control buttons the learner can interact with the experimentation objects and the set-up parameters are sent through the interface of

the solution that offers real time information (Calculation, diagrams, etc.). That solution suffers from many limitations. First of all, it requires real equipment which means additional costs for the tele-control equipment (cameras, network cables, etc.) and the installation of the experimentation. The maintenance also needs a considerable materiel and human resources; thus the laboratory equipment may need a periodic calibration and in this time, where the technician fixes the calibration problems, the system is down and no user is able to establish a connection to the system. Another drawback is that this solution is single access: only one student can do experiment but not all the learners at the same time.

Nowadays, there is a huge number of e-learning platforms that use virtual laboratories in various subjects, such as Biorefinery Virtual Laboratory (BVL) [22] (Fig. 1), a software that lets learners to simulate experiments in many scientific applied disciplines like biology, thermodynamics, electrical engineering, chemistry, among other ones. Another example is Virtual Chemistry Laboratory (VCL) Software that permits to model the positive influences on student achievement, to increase students' participation and it visualizes macro, micro, and symbolical level presentations of the experiment [23].



Fig. 1. Biorefinery virtual laboratory [22].

Virtual laboratories can solve the problems of the real laboratories equipment's costs, the safety of the learners (the learners are not safe when they are doing dangerous experiments) and also, the learners can repeat the experiments as much as they want. Nevertheless, this solution still suffer from some limits like the necessity of internet; the user (Instructor, learner, etc.) needs to be connected all the time during one's presence in the virtual laboratory, so if the internet connection is lost, the user may lost the unsaved data and have to start all over without forgetting to mention also the lack of virtual equipment setup experience and of hands on debugging experience and troubleshooting. Those virtual laboratories have a license limit to how many users can run the system simultaneously. In addition, the user still confined to use the keyboard, the mouse and sometimes joysticks [24].

3. Proposal

We propose an update for our proposed solution [10], that is a module of practical activities based on augmented reality and virtual-reality technologies that can be

integrated into many e-learning platforms. The update consists of guaranteeing the occlusion with the virtual objects in an attempt to make a more real interaction with the AR objects which have to obey to the laws of physics.

In our solution, we have three actors: the learner who is the main user of the practical activities, the instructor and the designer who are the users charged of the creation and the test of the practical activities.

The environment of the solution is divided into two parts hardware and software. For the hardware part, the users of this system need a computer connected to internet to download the needed 3D objects from the platform, to load the created ones by the designer and to upload the practical activities to the platform, and to download the virtual experimentation that the learner can execute and manipulate later. Besides that, the users need a webcam or a Kinect camera to ensure the augmented reality space generation and finally a leap motion to guarantee the hands' gestures detection.

As software, the designer uses 3DS MAX [25], that is a modelling, animation and rendering software, to create a new 3D lab objects and to modify the existent ones in the "Objects Database". For the creation of the practical activity, the scenario is built using OpenSpace3D "OS3D" [26], which is an open source software designed to offer an easy way to create a whole interactive virtual and augmented reality applications without need of software development skills to use it.

The designer starts the creation of the practical activities in OS3D by ensuring the interaction between the learner/instructor and the virtual 3D objects. There are several ways to guarantee this interaction, like the use of markers to control the objects' reaction (moves, rotation, etc.) or using a stereo camera that has to be configured to detect the skin color and the hand gestures to manipulate the virtual objects [27]. A third way, that our designer adopts, is using a leap motion that detects the user's hands and their gestures with its sensors [24].

In our case, the designer uses the leap motion sensor and its PlugIt in OS3D. S/he is able to know the position of the user's hands, their rotation and gestures. In OS3D, the virtual world, where the virtual objects are presented, is superposed on the real world that comes from webcam or the Kinect. Consequently, a problem of a contact between the users' hands and the objects is impossible. To fix this problem, a virtual hand is added to the virtual world and is superposed on the real hands to copy their moves (Fig. 2).



Fig. 2. Superposition of virtual hand on the real hand.

The objective of the AR is to add virtual object to the real world video scene. The realistic merging of virtual and real objects requires that the augmented objects have to be correctly occluded by foreground objects [28]. To ensure the occlusion in our solution, the designer applies an additional material "TransShadow material"; that renders the virtual objects with this material transparent and deletes its pixels, on the virtual superposed hands and gives the user's hands the possibility to appear behind and in front of the virtual objects (Fig. 3).

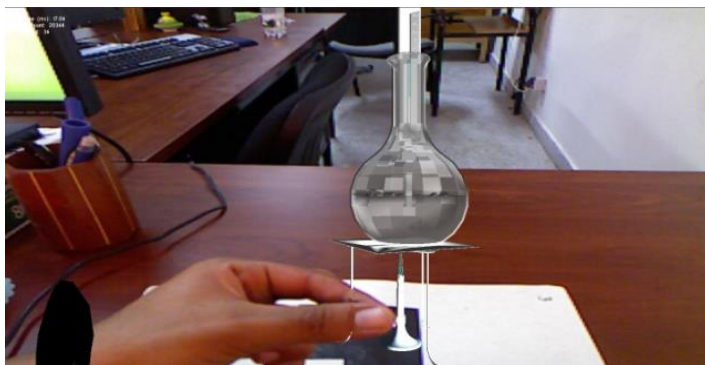


Fig. 3. User's hand after the application of the "TransShadow material".

After that the designer completes the first phase, s/he proceeds to the creation of the practical activities in OS3D by adding the virtual equipment in the zone of "List of the loaded objects" (Fig. 4). S/he modifies their materials, scale, position, orientation and their physic options (the body type, body size, mass, fluid or solid, etc.) in the scene. Then, s/he realizes the scenario of the practical activity in bottom area the "Zone of function" which is based on the drag and drop of the "PlugIt".

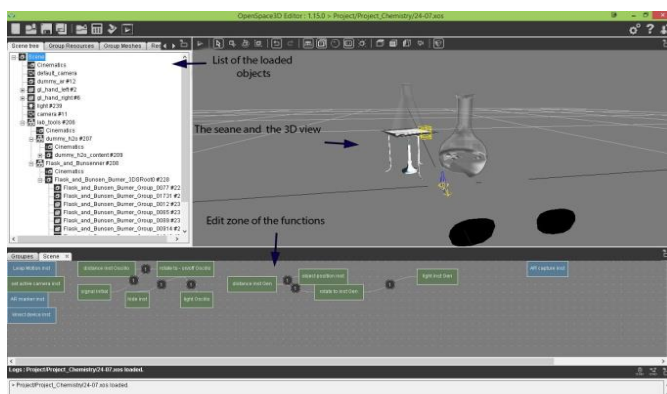


Fig. 4. OS3D the designer's workspace.

When the designer finishes the realization of the practical activity, s/he sends it to the instructor, which in her/his turn, tests it and verifies if all the information in the delivered description are present. Afterward the final confirmation, the instructor loads the practical activity in the "Practical Activities Database" to the learners.

For the learners', they just need "OpenSpace3D Player", a plug-in for navigators that gives the possibility to launch the "virtual environment". "OpenSpace3D Player" is a passive part of the software where the user doesn't have the privilege to modify anything in the project's scene.

4. Results and Discussion

4.1. Presentation of the target population

The sample for this study is composed of a designer who is a qualified person with developed skills in 3D design; he also took training in how to use OS3D, a professor of chemistry and a group of freshmen students in Chemistry Department, chosen randomly. This group included 20 students (11 males and 9 females). It is noteworthy that none of the learners had any experience or contact with the solution before.

4.2. Preparation of the practical activity

The instructor prepared a detailed description of the first part of the practical activity containing the process of practical activity and its necessary equipment. The designer receives the description, begins listing objects of the practical activity, checks the existing objects in the "Objects Database", downloads the needed ones, creates the no-existent ones and starts the creation of the practical activity.

In our case, the designer receives that the learner has to determine the boiling water temperature. To do so, a learner needs a 'Burner', a 'Beaker containing water' and a 'thermometer'. When the designer finished the preparation of the virtual practical activity and sent it to the instructor, this latter had to verify it and give the remarks and the modifications to the designer to get them rectified. As a final step the instructor would load the practical activity to the learners (Fig. 5).

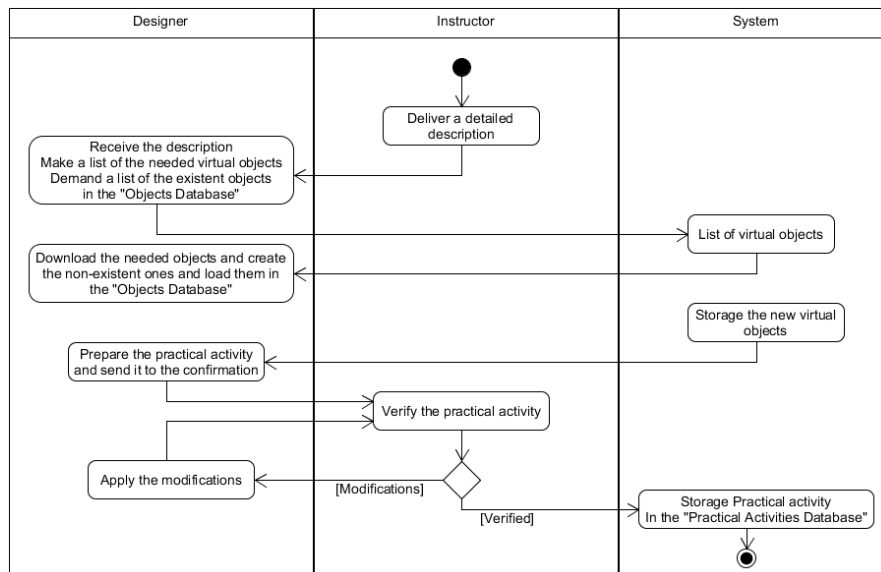


Fig. 5. Activity diagram of creation of the practical activities.

4.3. Integration of the practical activity in the platforms

After completing the preparation of the practical activity and verifying it, the instructor exports the web version from OS3D. He loads it in the platform (eMouss@ide or Moodle), gives it a title and a description, chooses the level and the domain and by the end loads the instructions' file.

4.4. Realizing the practical activity

The learner, after opening one's account in the platform, can have access to the enabled practical activities. S/he can practice the practical activities online or download them and practice them offline. Before starting the practical activity the learners must connect their leap motion and webcam and read the description of the practical activity (learners' version).

The learners of the first year of Chemistry Department check their first practical activity and read the instructions that the instructor uploads. The learner must take the 'Beaker with water', put it on the 'Burner' and light it to heat the water until boiling, and finally put the 'thermometer' in the 'Beaker' (Fig. 6). After that, the learner has to observe the change of temperature every 10s and draw a diagram using these values. To observe closely the marked value in the 'thermometer', the learner can form a fist with her/his hand (Fig. 6).

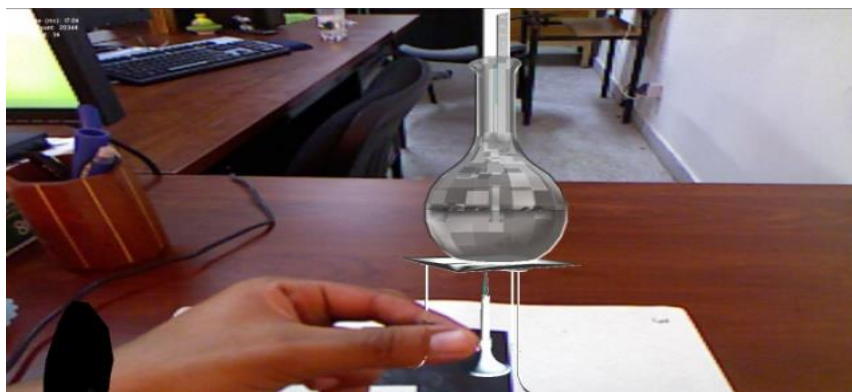


Fig. 6. The practical activity in the "Augmented laboratory".

4.5. User evaluation and survey result analysis

The objective of the evaluation of the solution is to measure its usability and effectiveness on the users. Therefore, a survey was distributed and handed out to the learners, the instructor and the designer to complete it after the practical activity.

The response frame to the learners' questions (Table. 1) was structured as a five-level Likert item. In our analysis we consider for every questions (Learners: A, B, C, E, F, G, H, I. Instructor: A. Designer: A, B) the first two responses: positives, the last two responses: negatives and the middle one is neutral (Fig. 7), the rest of the questions (Learners: D. Instructor: B and for the designer: C) are qualitative questions to which the user must give an answer.

Table 1. Questionnaire performed to obtain users' feedback.

<p>Learners/Instructor</p> <p>A. The accessibility to the practical activity?</p> <p>B. How clear was the practical activity's description?</p> <p>C. Were you able to use the practical activity with ease?</p> <p>D. What are the difficulties that you found while performing the practical activity?</p> <p>E. Did you find the tool helpful?</p> <p>F. Are you satisfied or dissatisfied with the virtual practical activity?</p> <p>G. Comparing to the traditional way, how would you rate the virtual practical activity?</p> <p>H. Which grade will you score the quality of the virtual practical activity?</p> <p>I. Which grade will you score the manipulation of the 3D objects?</p> <p>Instructor:</p> <p>A. How was the communication with the designer?</p> <p>B. What are the problems encountered with the learners during the experimentation?</p> <p>Designer:</p> <p>A. How was the communication with the instructor?</p> <p>B. Do you agree or disagree that the creation of the virtual objects was easy?</p> <p>C. What problems did you face during the creation of the virtual practical activity?</p>

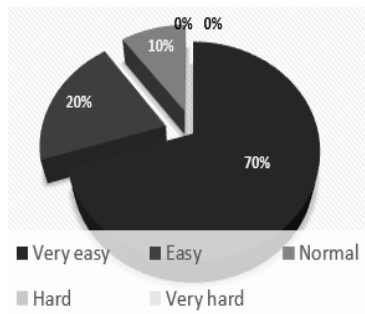
The majority of learners have generally confirmed that the accessibility to the practical activity was easy and its description was clear, contrariwise no student has claimed a problem concerning either the accessibility to the practical activity or its description.

The virtual practical activities are a new concept for the students. Thus, an initiation was carried out in order to help them to get familiar with this tool. Consequently, it was seen that 60% of respondents agreed that working on this virtual practical activity was easy. The rest of the students (40%) claimed that the major problems are the precision of the hand's gestures (25%) and the manipulation of the 3D objects (15%). But basically, the tool was appreciated and was found helpful by the majority of students (80%). Working with the virtual practical activity was reported useful comparing to the traditional way (75%).

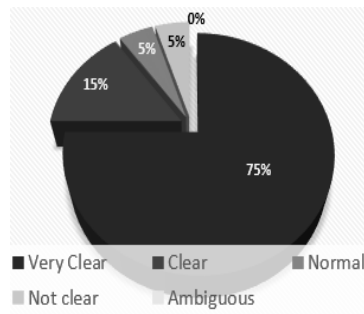
Assigning a score to the quality of the practical activity equipment and the manipulation of the 3D objects, only 10% of the students were not satisfied.

The instructor in one's turn answered the questions dedicated to the learners and he found the accessibility to the practical activity and the use of this virtual environment was easy. In addition, he was strongly satisfied about the usefulness of the proposed tool.

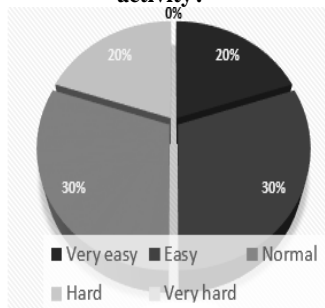
Compared to the traditional practical activity the instructor found the virtual one easy to prepare, and at the end, there was no need to collect the equipment. The instructor gives a positive answer about the quality of the virtual practical activity and has a simple remark concerning the realistic of the 3D objects so the designer must work more on the quality of the 3D objects, but their manipulation was so good.



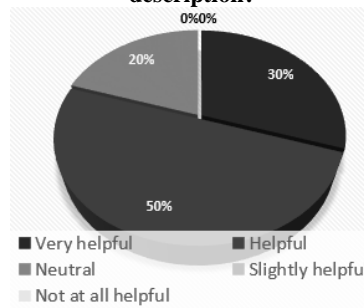
(a) The accessibility to the practical activity?



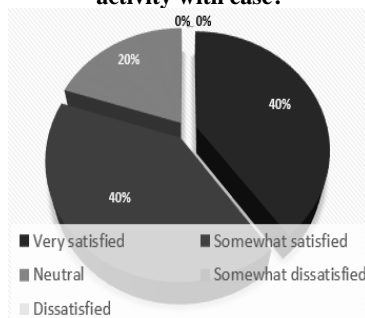
(b) How clear was the practical activity's description?



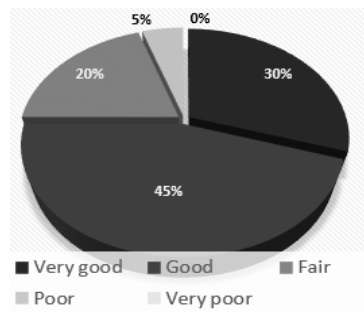
(c) Were you able to use the practical activity with ease?



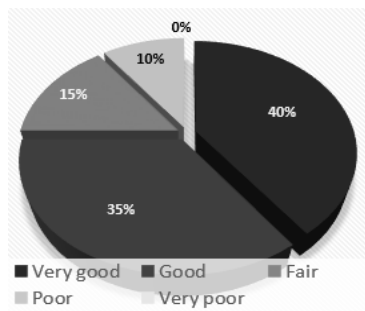
(d) Did you find the tool helpful?



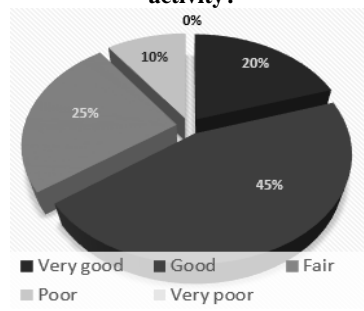
(e) Are you satisfied or dissatisfied with the virtual practical activity?



(f) Comparing to the traditional way, how would you rate the virtual practical activity?



(g) Which grade will you score the manipulation of the objects in the virtual practical activities?



(h) Which grade will you score the manipulation of the 3D objects?

Fig. 7. Student questionnaire results.

The instructor agreed that the communication (direct contact and with e-mail) with the designer was fluent. According to the survey results, the instructor has claimed that the major problem is that the learners are not familiar with this kind of practical activities, so they needed more time to be adapted to it. In addition, the instructor determinates a few problems encountered by the learners: as a first contact the learners need an initiation to the application and its equipment (leap motion and camera) how to use them, how to catch and manipulate the 3D objects and an explanation of the practical activity (the description) and the desired result.

From the designer's point of view, the description wasn't clear from the first time so he re-contacts the instructor several times (without any problems) and clarified the description. For the realization of the practical activity, the use of OS3D simplified the insertion of the 3D objects in the scene and the "plugits" gave a lot of options and facilitated the configuration of the physical contact between the objects and their orientations and positions etc.

4.6. Discussion

In this paper, we proposed an E-learning platform based on mixed reality. The aim was to facilitate the creation and the integration of practical activities for students. The use of mixed reality enabled the resolution of constant issues encountered during the use of the real equipment's distance control, virtual laboratories or even videos: the high price of the purchase, the installation and the maintenance of real equipment, the unique or the limited access to a workshop and the lack of interactivity between learners and the recorded practical activity.

The use of OS3D made the creation of the practical activities easier due to the integration of the 3D objects and their animations in the software's work scene. Other advantages can be highlighted namely: ensuring the interaction between the learners and the 3D objects and facilitating their configuration and allowing a quick start of the practical activity as well as its closure.

The existent solution [10] proposes virtual hands superposed on the user's real hands to manipulate the 3D objects, which gives an undesired virtual impression and simulates indirect contact with 3D objects. So, the integration of the « TransShadow.material » as a material is necessary to ensure occlusion in the proposed solution and to make the virtual hands transparent by removing their pixels.

5. Conclusion

The practical activities are an essential part in the pedagogical cycle. But unfortunately, they are suffering from several problems that prevent the good progress of the course like the high price of the equipment, the users' safety, freedom of using the laboratory and the time limitation of using the equipment, etc.

In order to overcome these issues, many E-learning platforms that may integrate videos, virtual laboratories or even tele-control of real equipment were created. Despite all these proposals, the e-learning platforms suffer from several limitations: the use of videos suffers from the no-interactive, the use of virtual laboratories requires Internet connection all the time and using real equipment means additional cost for the connection equipment (cables network, cameras,

etc.) also the performance of the experiment must be done individually that will cause a huge loss of time.

As a solution, we present in this paper, a dynamic proposition based on the augmented reality and the augmented-virtuality technologies. It reduces the cost of the real laboratory equipment and the learner can perform practical activities safely without fear from dangers that s/he can confront (chemical, electrical, nuclear, etc.). The proposed process is generic in terms of the practical activities' creation and adaptable to every kind of practical activity.

The instructor and the designer prepare the practical activity together; the first one is responsible for providing a detailed description of the practical activity's progress with a list of the needed virtual 3D objects. Based on the description, the designer creates the practical activity, its 3D objects and animations. The learner just needs a webcam, a leap motion and a computer where the practical activity is already downloaded from one's account in the e-learning platform.

To evaluate the proposed solution, a feedback containing the opinion of the different users is required for future improvement. To do so, a survey was given to the learners, the instructor and the designer. The results of this survey show that the majority of the users were satisfied with the advantages that the proposed solution (the augmented laboratory) offers compared to the traditional practical activity. Some advantages can be added to what have been said before, starting by the time gained during the launch and the closure of the practical activity to the motivation that this new concept gave to the learners enabling them to perform and discover more practical activities. However, despite some difficulties encountered by the users, their opinions still positives and the proposed solution meets their needs.

Thus, for future work, we will improve the hands gesture recognition and the manipulation of the 3D objects. As well as eliminating the Leap Motion to reduce the price of the used equipment, we can ensure a direct interaction between the user and the practical activities' 3D objects.

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