Exploring the possibilities of augmented reality in physics education

Ayaichi Laila*, Bouras Nihal, Amaaz Aziz, Mouradi Abderrahman, El Kharrim Abderrahman

Laboratory Of Applied And Didactic Sciences, Abdelmalek Essaadi University, Tetouan, Morocco

*laila.ayaichi@etu.uae.ac.ma

Abstract :

Several research has shown that the application of augmented reality (AR) in physics can improve student understanding, involvement and inspiration. In the field of physics, AR may be used to enhance students' experience of practical work (TP) by helping them to visualise abstract concepts, simulate dangerous or expensive experiments, or explore phenomena that are difficult to reproduce in the laboratory. This section highlights the opportunities offered by the the integration of AR objects in teaching physics. It points out that the using AR tools intensifies the realism of studies, offers an enriching the emotional and intellectual process, and support to engage students in a structured training.; provides correct information about the facility being experimented with. This work aims to describe the efficacy of using augmented reality-based learning materials in learning physics experiments using an augmented reality application. The students' knowledge acquisition was measured using the pre- and post-testing method. The participants were 370 university students of Bachelor of Education, specialising in primary education. They have been allocated to an intervention group or a reference group.. In conclusion, the article highlights the benefits of using augmented reality in physics laboratories and encourages teachers to explore this technology to enhance student learning.

Key words:

augmented reality; wiring; series connection; parallel connection; physical laboratory; motivation.

1. Introduction :

In recent years, new pedagogical approaches, including the use of computer-assisted teaching and learning has become an innovative and effective solution for distance learning, representing promising Solutions to replace conventional approaches. (Losco et al, 2017). In parallel, augmented reality (AR) technology stands out by integrating the physical environment with digital data, enabling the projection of images, such as holograms, onto a tangible background (Uribe et al., 2023).

Augmented reality represents a technological category that empowers users to perceive their physical environment while superimposing virtual elements on tangible items through a 3D recording proceeding. Instead of completely substituting reality, AR acts as an enrichment of the real environment (Azuma, 1997,Sunil et Kumaran Nair, 2017). In agreement with the work

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of Azuma et al (2001), this technology is defined by three major aspects: the fusion realistic and virtually objects within a concrete environment, actual -time interactive functionality, and the mutual registration of virtual and real objects. AR offers exceptional pedagogical possibilities, such as mobility, visualization, access to other perspectives, This facilitates the comparison and contrast alternative viewpoints, of our integration of different perspectives. The incorporation of augmented reality into the learning process, supported by an appropriate formative assessment device, significantly enhances learner motivation, while optimizing the knowledge acquisition process and reducing their cognitive load (Muliyati et coll., 2019).

A survey conducted in 2017 by Akçayır & Akçayır (2017) reveals that mobile devices are the main preference for using augmented reality technologies due to their ease of use, portability and cost, compared with laptops or desktops. The application of augmented reality techniques offers learners the possibility of sensory learning experiences that, in certain situations, surpass those provided by traditional teaching methods (Andujar et al., 2011). Various researchers have examined the pedagogical possibilities handsets, emphasizing their relevance in educational environments and weighing up the multiple applications of this enabling technology. (Cadavieco et coll., 2012). As an example, in a science class, a teacher can overlay visual data onto the textbook, offering students the opportunity to view it in detail via their mobile devices. This enables in-depth observation of resources usually unavailable in the classroom, such as a turbogenerator when studying energy and its transformation (Del Cerro Velázquez & Morales Méndez, 2018). Thanks to the use of mobile devices, students can access the information or knowledge they need at any time and in any place (Hwang et coll., 2011).

Augmented reality offers the possibility of carrying out scientific experiments such as chemical reactions, that would be difficult to achieve in reality (Arymbekov et al., 2023). In addition, it enables The illustration of concepts such as air displacements or magnetic fields, as well as occurrences, by juxtaposing virtual components with concrete objects. (Tian & Günther, 2019). This technology enables an interactive and natural experience, allowing users to interact with these objects in an immersive way. Although augmented reality has been present in the consumer arena for some time, its gradual integration into educational environments is emerging. The interactivity inherent in augmented reality opens up prospects for constructivist learning, where users actively participate in developing their understanding of concepts through self-directed learning. Studies have shown that augmented reality contributes to the development of spatial abilities and offers cognitive advantages for learning, distinguishing it from traditional 2D displays.

2. Research purposes :

The primary aim of this investigation is to determine whether there is a substantial distinction between the skills of laboratory learners who integrate AR into their practical scientific tasks and those of learners who do not.

The secondary objective of the investigation is to identify whether there is a substantial distinction between the perspectives of learners who assimilate AR innovations into their practical scientific tasks and those of learners who do not.

3. Methodology:

The quasi-experimental design, a quantitative research method, was the basis of this study. When the experimental and control groups are not formed randomly, they are formed with pre-existing classes. In this situation, a quasi-experimental design is used.

3.1 participants :

All university students of the Bachelor of Education were participating, specialising on primary school teaching of the Ecole Normale Supérieure. 370 students took part in the study.In the academic year 2022/2023 we divide 370 students divided in two categories: Experimental group and control group. (see Table 1).

Table 1 : Classification of participants by genre and group.

Gender	Experimental group	Control group
Female	**111**	**105**
Male	**74**	**80**
Total	**185**	**185**

During six weeks we worked with 12 groups, each group consisting of 30 students and students divided into 7 groups of 4 people.

3.2 Research Methodology:

This investigation was carried out during physics experiments.. Firstly, we made explanatory videos that allowed the students to connect a simple circuit in series, and secondly, The students were split into two groups: a control group that worked on the experiments with the traditional laboratory manual, and an experimental group that made the experiments with the help of the videos made and integrated into their manual using artificial labels. The objective of the first video is to allow the students to know the different materials used in the physics laboratory and especially in electrics and to explain how to wire a simple assembly from the circuit scheme. The second experiment carried out allows the students to connect a parallel circuit using their diagram, then based on the same set-up carried out and an ammeter is added to assess the strength of the electric current. To measure the intensity of the electrical flow using an ammeter that is connected in series to measure the five intensities of the current flowing in the circuit, the objective is to find the relationship of the law of nodes. The last experiment carried out allows the students to see how a voltmeter can be connected in an electric circuit. The voltmeter is a measuring device that allows us to measure the electrical voltage between the terminals of a dipole, it is connected in parallel to measure the voltages U_{CD}, U_{AB}, U_{EF} and U_{GF}. Measuring different voltages allows students to understand how different tensions are linked and especially the law of mails. The students participating They were divided into two groups in this study: a groupe de contrôle that worked and carried Carry out a variety of experiments using their traditional laboratory manual, under the guidance of the teacher, and the experimental group that carried out the different experiments using their manual assisted with augmented reality. The only difference between the two manuals is the artificial label added to the experimental group's manual that gives the students direct access to the videos prepared by the teacher that explain the different steps of carrying out the experiments. (see Fig. 1). All the videos made are published in the learn.space platform with the use of the H5P activity. The H5P activity allows us to create an interactive video where The student must provide answers to the questions asked during the video and if their answer is incorrect then the video will be repeated so All questions must be asked by the student in order to complete the activity and move on to the next manipulation.

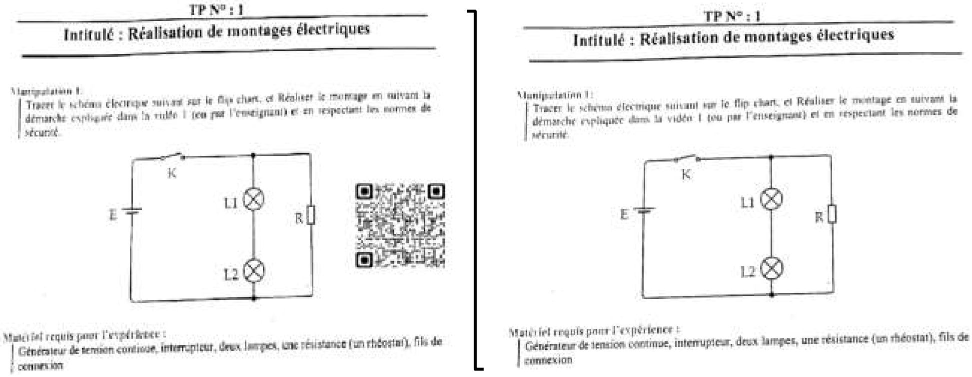

Fig. 1. the laboratory manuals for the experimental group (left) and the reference group (right).

3.3 Material :

Being better aligned with the objective of this study, image-based augmented reality was favoured. Rather than opting for natural graphics, artificial labels were selected for this modality, due to their faster and more accurate tracking. Four videos were produced to guide the students through the proposed manipulations. To enhance the augmented components of the platform, videos and links to additional documents were incorporated. For example, in the context of the Ohm's law experiment, scanning the QR code triggers the appearance of a four-minute explanatory video (Fig. 2), detailing how the experiment is carried out. All artificial labels were prepared using the apprendre.space platform (Fig 3).

Fig. 2. Interactive handling: Explore by scanning the QR code

Fig. 3. platform interface apprendre.space (experience of wiring a simple circuit)

3.4 The Data acquisition procedure :

In this research, A combination of qualitative and quantitative tools was used to obtain information. A form was administered to assess students' competence in the laboratory to gather quantitative information. results of the questionnaire were used as a pre-test and the results of the The terminal exam was used as a post-test (see Fig. 4).


Grille d'évaluation

Fig. 4. evaluation grid

3.5 Analysis of information carried out.:

Data were recorded using SPSS 16 software. A t-analysis was implemented to test whether or not there were statistically significant discrepancies between the laboratory skill scores of the comparison group and the experimental group. Similarly, a t-analysis was used to determine whether or not there was a significant discrepancy between the perspective scores of the comparison group and the experimental group.

4 Results :

Test student results for lab handling competences

The t-test findings reveal a remarkable divergence in favor of the experimental group, suggesting that the integration of augmented reality technology has elicited a positive impact on the laboratory skills of higher education students (see Table 2).

Table 2 : The scores of t-test for laboratory competencies

Variable	group	N	Mean	t	p
Pre-test	control	185	2,25	1,731	.088
	expérimental	185	1,99		

The conclusions of the t-test show No statistically significant results were in the pre-test results between the experimental and control groups. An additional t-test analysis was performed in order Identify any significant disparities between the results of the two groups in the subsequent evaluation.. Les résultats ont montré que les groupes étudiés différaient considérablement (see Table 3). It is possible to conclude that the laboratory skills of higher education students are enhanced by AR technology.It is can be to conclude that the laboratory competencies of higher education students are enhanced by augmented reality technology.

Table 3 : The results of the t-tests for the detection test laboratory skills of the experimentale and test team.

Variable	group	N	Mean	t	p	Cohens d
Post-test	control	185	2,92	2,436	.017	.567
	expérimentale	185	3,22			

The t-test results show a major disparity to the advantage of the experimental group, suggesting that augmented reality technologies can help university students develop their laboratory skills.

4.4 t-test scores for the assessment of attitudes in the physics laboratory between test and control groups.

Group attitudes scores were closely aligned prior to the introduction of augmented reality, with no significant differences observed between them (see table 4).

Table 4 : Results of test student for the physics attitude scale for control and test team

Variable	group	N	Mean	t	p
Pre-test	control	185	3,41	1,224	.225
	expérimentale	185	3,33		

Following implementation, the orientation assessments The number of students in the experimental group has grown, and a considerable number of learners in the experimental group have experienced an increase. disparity between groups has been detected (see Table 5). AR technology seems to have had a positive impact on students' outlook towards practical work in physics.

Table 5 : test student of attitude results towards electronic laboratories of both team (post-test).

The Variable	group	N	Mean	t	p	Cohens d
Post-test	control	185	3,54	2,813	.006	.678
	expérimentale	185	3,76			

5 Discussion and conclusion :

This research examined the impact of using AR technology in a scientific laboratory on academic students' abilities and attitudes toward AR technology. practical physics work. The results of the experiment show that AR technology has a beneficial impact on pupils laboratory skills. What's more, these results add to the existing literature (Ibáñez & Delgado-Kloos, 2018, Luquerna & Diaz, 2022) The findings of this research are extremely encouraging for using AR innovation in science education. Not only does it allow students to visualise phenomena that would otherwise be impossible to observe in a traditional laboratory environment, but it can also help students learn laboratory skills more quickly and effectively. AR technology could also transform the way teachers teach science by enabling more interactive and immersive lessons. By providing a more engaging and stimulating learning experience, students may be more motivated to pursue science in the long term. The results of this research clearly show that using AR technology can have a important impact on students' laboratory performance. By allowing more detailed and interactive observation of scientific phenomena, AR components such as video can help students to better understand scientific concepts and acquire laboratory skills more quickly. Furthermore, student-content interaction is essential for effective learning, and AR components can help to enhance this interaction by allowing students to manipulate and explore content in a more immersive way. This can make learning more interesting and engaging for students, which in turn can improve their performance in the lab. This finding is also very significant as it suggests that using AR technology can not only enhance students' achievements in the lab, but also speed up the learning process. Another significant result of In the present study, The students carrying out the experiments completed their manipulations in a very short space of time.In addition, this finding may also have practical implications for educational institutions, as it could potentially reduce the time needed to conduct laboratory experiments, which can have a positive impact on the cost and availability of laboratory resources. This is a very interesting finding that suggests that using AR technology may have a importance influence on the tlearn experience of students in the laboratory, improving not only their performance but also their attitude towards these experiences. It is possible that using AR technology has expanded student engagement with the laboratory experiments, making them more interactive, immersive and interesting. Students may also have appreciated the ability to visualise complex scientific concepts in 3D, which can make these concepts easier to understand and remember. This study shows an example of how a smartphone (which students already own) The study highlights how the use of mobile devices within a laboratory can help improve students' laboratory skills. Future research should further evaluate the findings of this research by testing the efficiency of using AR to teach other physics experiences - augmented reality can be used to create interactive simulations that allow students explore physics notions in a more appealing and intuitive manner. For example, pupils can use AR to explore the behaviour of waves or to simulate the behaviour of subatomic particles.

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