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PAPER

Impact of Augmented Reality via Mobile Technology on Student Performance in Physics Practicals Work

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ABSTRACT

The current study was conducted to investigate the effect of using augmented reality (AR) via mobile devices on students' performance in practical physics work. The study involved 108 second-year bachelor students specializing in physics and chemistry at the Higher Normal School of Abdelmalek Essaadi University. In this experimental study, the students were divided into two groups: an experimental group and a control group. The results indicate that using AR via mobile devices positively impacts students' performance in practical physics work and significantly reduces the time required for the experimental group to complete various experiments.

KEYWORDS

physics practical work, augmented reality (AR), mobile devices, mobile technology support for students

1 INTRODUCTION

As defined by Azuma [1], augmented reality (AR) can be considered a visualization system or method that plays three fundamental roles: merging virtual and real environments, enabling real-time interaction, and ensuring accurate capture of virtual and real objects in three dimensions [2]. AR has established itself as a transformative technology in a variety of fields, dramatically improving the user experience and interaction with the real world [3]. Education is one area where the importance of AR is particularly pronounced [4]. Today, AR is integrated into all stages of education, from primary and secondary schools to higher education establishments [5].

In educational study and practice, AR is characterized by the superimposition of real-world digital data, providing learning frameworks different from the traditional approach, and encouraging innovative perspectives on knowledge acquisition mechanisms [6]. In higher education, AR can optimize both organizational and pedagogical processes, creating an effective and interactive learning environment that encourages a shift from a teacher-centered to a learner-centered

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educational approach. This shift allows for more interactive, personalized, collaborative, and problem-solving-oriented learning experiences that are adapted to students' needs [7].

Augmented reality is an advanced technology that merges the real world with the virtual world, enabling users to interact with computer-generated visuals, text, sounds, and other effects [8], [9]. In educational environments, the use of AR technology stimulates student engagement and motivation by fostering interaction between the real and virtual realms [10]. This technology enables educators and students to visualize information that would otherwise be inaccessible in a real-life context, thus facilitating the visualization of numerous scientific concepts that were previously unable to be illustrated in a clear manner [11]. Consequently, AR facilitates the teaching-learning processes, rendering them more engaging and motivating [12], [13]. Indeed, one of the most frequent applications of AR in education is to complement school materials or those prepared by the teacher in written form [14].

Augmented reality is a technology that seamlessly integrates the physical and digital realms, utilizing readily available, emerging technologies such as smartphones and tablets. This convergence enables the creation of an alternative, unprecedented reality [15]. The use of AR via mobile devices offers significant advantages in learning, not least due to the ease of use, portability, and affordability of these devices compared to laptops or desktop computers. Furthermore, there is evidence that AR has a positive impact on students' academic performance when studying abstract physics concepts [16]. It offers students a powerful method of visualizing complex and abstract physical concepts in an interactive and engaging manner. Additionally, it can be utilized to create scientific laboratory simulations, thereby enabling students to conduct experiments without the necessity of costly or hazardous equipment [17].

In the context of physics education, AR facilitates the direct visualization and manipulation of phenomena such as gravity, forces, and electromagnetic fields within a tangible environment, thereby enhancing the practical comprehension of complex concepts [18]. Furthermore, AR capabilities such as image recognition, motion tracking, and plane detection support interactive sessions that allow students to visualize dynamic 3D models of objects and concepts, significantly enriching the teaching of physics [19]. A number of studies have demonstrated that students hold a positive perception of the usefulness of AR in physics courses and that the integration of this technology as a teaching aid has a positive impact on their motivation [20], [21], [22].

Augmented reality technology not only enhances the learning experience by providing unique visualizations and interactions with three-dimensional virtual objects but also addresses challenges associated with the use of laboratory equipment, thus facilitating learning in a practical setting [23]. Laboratory work is often considered by educators to be a cornerstone of effective science education because of its unique ability to provide practical and tangible experience with theoretical concepts, contributing significantly to a deeper understanding of laws and physical phenomena [24]. The benefits of practical work (PW) in science education are widely recognized as providing diverse learning experiences and fostering 21st century thinking skills; students who can objectively analyze and evaluate information can develop critical thinking skills and solve complex problems [25]. In physics, in particular, laboratory work allows students to experiment with and study the physical world by manipulating and observing real objects [26]. The integration of AR technology into physics labs represents an innovative leap forward in providing an immersive approach to science learning in higher education. AR enables the three-dimensional visualization of physical phenomena and the performance of virtual experiments without physical constraints, enhancing personalized learning, facilitating remote access to practical sessions, and increasing student engagement and motivation [27]. It also promotes the acquisition of complex problem-solving skills and can be adapted for use as a blended or distance learning tool [28], [29].

Previous studies have reported that the use of AR via mobile devices has a positive effect on students' motivation, skills, and attitudes towards physics PW, highlighting its role in enhancing the laboratory learning experience [30], [31], [32], [33], [34], [35]. Although the impact of using AR via mobile devices on students' motivation and attitudes during such experiments has been widely studied, little work has examined its influence on students' performance in physics labs using mobile devices. What's more, this performance study has shortcomings, such as a lack of comparisons with traditional teaching methods and a lack of objective measures to assess the effectiveness of AR. The need for methodological clarification and further analysis is also highlighted, indicating the need for greater rigor and clarity in study on this topic. In this context, this article aims to fill some of these gaps by investigating the effect of using AR via mobile devices on university students' performance during physics laboratory sessions and comparing this effect with that of traditional hands-on methods. Adopting a more holistic approach, the study evaluates these performances according to three different criteria: practical performance, time spent on experiments, and the quality of laboratory reports. In this way, it aims to provide a more comprehensive and nuanced assessment of the impact of AR on students' performance during physics PW. This multi-criteria approach makes it possible to capture the different facets of the effectiveness of AR technology in this specific educational environment. Thus, the guiding question of this study is: Is there a significant difference in performance between students who integrate AR via mobile devices into their physics PW and those who do not?

2 RESEARCH METHODOLOGY

In Moroccan higher education, PWs are widely used in various areas of physics. They are an essential part of scientific education, providing students with the opportunity to put into practice the theoretical concepts studied in class. These include mechanics, thermodynamics, electronics, etc.

Electronics theory provides the foundations and basic concepts; however, PW allows students to experiment with these concepts, analyze the behavior of circuits, and understand the intricacies of electronic components. PW bridges the gap between theoretical principles and their practical implementation, reinforcing students' knowledge of electronics and effectively preparing them for future professional challenges. With this in mind, PW sessions are included in the program for Moroccan students studying for a degree in education, specializing in physics and chemistry. The Bachelor of Education in Physics and Chemistry includes theoretical courses in physics followed by PW, which allows students to apply their knowledge through concrete experiments.

As part of this study, a Moodle LMS platform adapted for mobile devices was developed and made available to all students (see Figure 1). The platform was used to provide AR resources so that students could complete assignments involving multiple assemblies or experiments. AR technology was integrated into this platform to provide students with an immersive and interactive learning experience. This integration is based on the use of QR codes strategically placed on laboratory equipment (stabilized power supplies, meters, resistors, etc.) (see Figure 2) and practical worksheets (see Figure 3). These codes provide access to a number of additional visual resources stored on the LMS platform. These resources include explanatory videos detailing the various steps involved in conducting the experiment, images describing the name and function of each device within an electrical circuit, and documents outlining the safety standards to be followed for each experiment. In addition, the experimental assemblies were captured as 360-degree photos, allowing students to virtually view these components and their configurations from their mobile devices. This approach allows for a detailed exploration of the current experiments as well as each component of the assemblies. By providing access to additional resources such as videos and images specific to each component, these photos facilitate access to enriched content. In addition, these photos are utilized to provide students with assessment activities designed to evaluate their ability to identify the conditions of use for each component, understand the purpose of each manipulation, and comply with appropriate safety standards. The accessibility of these resources via mobile devices offers flexibility in learning, enabling students to benefit from this enriched content regardless of their location.

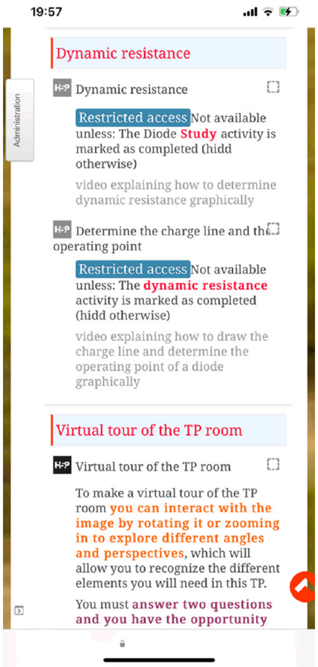
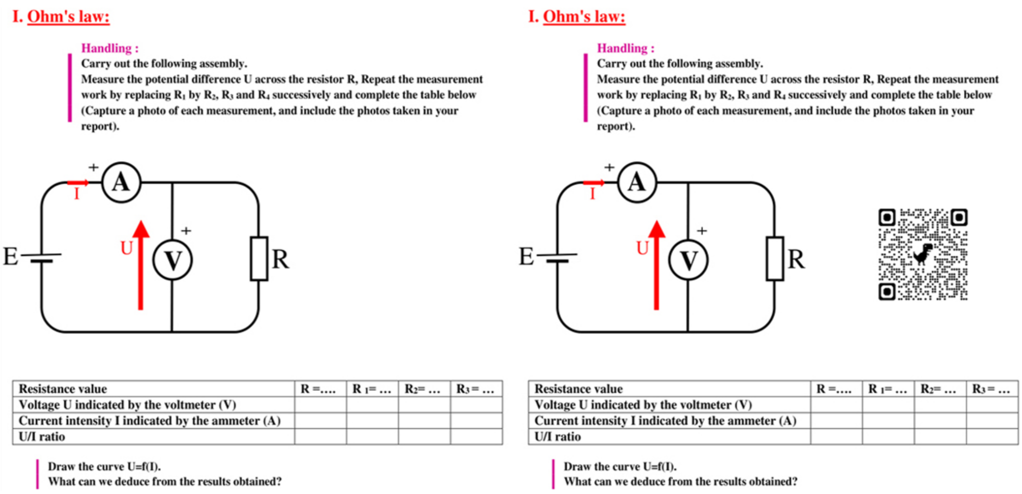


Fig. 1. Screen capture of PW activity on the LMS platform

Fig. 2. Application of QR codes on laboratory equipment: practical example

The sample size for this study was 108 students, all in their second year of a bachelor's degree in education, specializing in physics and chemistry, at the Higher Normal School of Abdelmalek Essaadi University in Tetouan, Morocco. The 108 students were the ones who agreed to participate in the study out of those who were accessible to us. To ensure group equivalence, the students were randomly divided into two separate groups: an experimental group and a control group, both with the same number of participants. Participants were randomly assigned to either the experimental group or the control group through a lottery process. This method was used to ensure a balanced and random distribution between the two groups, thereby reducing the risk of bias and ensuring the validity of the study results. The experimental group was exposed to the use of AR during the practical sessions, while the control group followed the PW using conventional laboratory teaching methods, including face-to-face demonstrations, verbal instructions, and direct interaction with the equipment under the supervision of the instructor (see Figure 3).


I. Ohm's law:

Handling :
Carry out the following assembly.
Measure the potential difference U across the resistor R, Repeat the measurement work by replacing R_1 by R_2, R_3 and R_4 successively and complete the table below (Capture a photo of each measurement, and include the photos taken in your report).

Resistance value	R =....	R 1= ...	R2= ...	R3 = ...
Voltage U indicated by the voltmeter (V)				
Current intensity I indicated by the ammeter (A)				
U/I ratio				

Draw the curve U=f(I).
What can we deduce from the results obtained?

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U/I ratio				

Draw the curve U=f(I).
What can we deduce from the results obtained?

Fig. 3. Screenshot showing the experimental laboratory manuals on the right and the control groups on the left

In our study, we scrupulously respected two essential aspects: obtaining informed consent and maintaining the confidentiality of the data collected. First, we were careful to obtain informed consent from all study participants before data collection began. This means that each individual was informed of the aims, procedures, and implications of the study and gave their voluntary and informed consent. We also ensured that the confidentiality of the data collected was maintained through stringent measures to protect the identity and personal information of the participants. All data were processed anonymously and securely, and only members of the study team had access to this information.

Prior to the start of the experiment that is the subject of this study, a preparatory session was organized to distribute login credentials and provide instructions on how to use the LMS platform via mobile devices. This was followed by two training sessions of two hours each to familiarize students with the use of AR through the LMS platform and mobile devices in physics PW. In this study, students in the experimental and control groups completed three manipulations (Ohm's law, Kirchhoff's law, and a study of diodes) over a period of eight weeks. Table 1 provides a detailed description of these three experiments:

Table 1. Objectives, materials used, and tasks assigned to students in the control group and experimental group for the three experiments carried out in this study

Manipulation Theme	Duration	Objectives	Material Used	Manipulation
Ohm's law	2 hours	Calculate the resistance value using a color code; Measure the value of a resistor using an ohmmeter; Measure current, voltage, and resistance using a multimeter (direct measurement); Measure resistance indirectly using Ohm's law.	Stabilized power supply Switch Ohmic conductors Ohmmeter Amperemeter Voltmeter Connection wires	The students first estimated the values of the Ohmic conductors, then measured them with an ohmmeter, and finally confirmed Ohm's law by varying the voltage and measuring the current.
Kirchhoff's laws	2 hours	Carry out various electrical set-ups (series, parallel, and mixed); Check Kirchhoff's laws (knot law and mesh law).	Generator switch Ohmic conductors Ohmmeter Amperemeter Voltmeter Connection wires	In this practical session on electricity, the students measured the current to check the law of nodes and then established the law of meshes by measuring the voltages across three Ohmic conductors in series.
Study of the diode	2 hours	Draw the I = f(V) characteristic of a junction diode in the forward and reverse directions; Determine the static and dynamic resistance of this diode; Determine the threshold voltage and the operating point of this diode.	Stabilized power supply Switch Junction diode Voltmeter Amperemeter Connecting wires	The students measured the dynamic resistance and threshold voltage of a diode using an ohmmeter and a voltmeter. They then set up two circuits with the diode in forward and reverse bias, recording the voltage and current measurements. Based on this data, they plotted the diode's characteristics, calculated the dynamic and static resistances, and determined the operating point.

During the first PW (Ohm's Law) session of the experiment in this study, QR codes were associated with each piece of laboratory equipment. By scanning these codes with their mobile devices, students in the experimental group could access information about each laboratory component and piece of equipment on the mobile learning platform. In addition, by scanning the QR codes on the PW sheets, these students could watch explanatory videos on the LMS platform that demonstrated how to perform the various setups and take the required measurements. The control group performed the experiments using traditional PW sheets. The teacher presented the objectives and materials at the beginning of the practical session and occasionally intervened to help groups in difficulty when requested (see Figure 4).

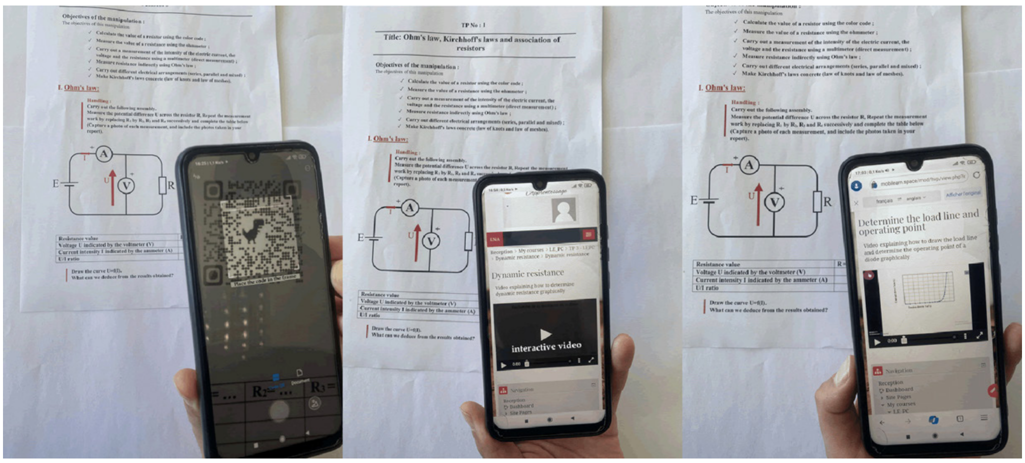

Fig. 4. Step-by-step view: Access to the LMS platform by scanning a QR code

During the second PW session (Kirchhoff's laws), the experimental group used a laboratory manual supported by AR to visualize the experimental setups to be performed in 360 degrees. For each setup, a 360-degree photo was taken and made available on the LMS platform. These images allowed students to visually explore each experimental setup, identify the equipment used, and access explanatory videos detailing the steps involved in building them, as well as the detailed structure of each assembly. In addition, formative assessment activities were provided to test the students' ability to assemble the experimental components and understand how they worked. In contrast, the control group followed the teacher's instructions using the traditional laboratory manual.

During the third PW session (diode study), the two methods used in the first and second tests were combined. The purpose was to evaluate the effect of using the two methods together on student performance. The control group performed an experiment under the supervision of the instructor using a traditional laboratory manual, while the experimental group opted for an AR-assisted manual. Before each experiment, students found a QR code that provided access to videos explaining the steps to be followed for the experiment, as well as a virtual tour of the diode experiment setup available on the LMS platform.

In this study, the participants' evaluation was based on three main criteria. First, the time required to complete the experiment was measured in minutes. Second, a grid was used to evaluate the students' practical performance during the hands-on experiments, including accuracy of measurements, rigorous application of experimental methods, adherence to safety standards, and ability to follow instructions correctly. Third, students were asked to write a detailed report documenting their participation in the experiments, including a description of the objectives, the methods used, the results, whether quantitative or qualitative, and analyses of the data collected. These reports were then corrected and graded. The second and third criteria were scored on a scale of 20 points each.

Normality and homogeneity tests were performed to assess the distribution of the data in the sample. The results of these tests indicate that the population is not homogeneous and that the data do not follow a normal distribution. These findings were taken into account when interpreting the results and selecting appropriate statistical methods.

3 RESULTS OF THE DATA ANALYSIS

Mann-Whitney tests were used to measure the effects of integrating AR via mobile devices into physics PWs. Three main assessment criteria were used to compare the performance of students in the two different groups: practical performance and report score, each scored out of 20, and time spent performing the manipulations. When there was a significant difference between the performances of the two groups, the effect size was calculated to quantify the magnitude of the difference [33]. This analysis was performed using SPSS version 21 software.

The results of the first PW, designed to assess student performance, are presented in Table 2. In the control group, the manipulations were performed according to the laboratory manual, while the experimental group used an AR-assisted manual with QR codes (refer to Table 2).

Table 2. Results of the Mann-Whitney test of the first PW to determine the impact of AR on students' performance in practical physics tasks

Assessment Criteria	Experimental Group (n = 54)			Control Group (n = 54)			Mann-Whitney Test U			
	M	SD	Mdn	M	SD	Mdn	U	Z	P	r
Practical performance	19.19	.26	19.15	15.09	1.82	14.33	.000	–8.99	.000*	.86[a]
Report grade	17.28	1.10	17	13.24	1.74	13	106.50	–8.37	.000*	.80[a]
Time	3.96	2.04	4	10.93	1.96	11	.000	–8.98	.000*	.86[a]

Note: [a]large effect size, [b]medium effect size, [c]small effect size, *p < .001.

The data presented in Table 2 show significant differences between the performances of students in the experimental group, who used QR codes as an AR tool, and those of students in the control group, who used conventional methods for their PW and experiment reports. The results show a clear superiority in the practical performance and report grades of the students in the experimental group compared to the control group, with a large effect size (r > 0.80). In addition, it was observed that members of the experimental group performed the experimental manipulations in significantly less time than those in the control group, also showing a large effect size (r > 0.80).

The data presented in Table 3 compares the results of the second PW between the control group, which consulted traditional manuals, and the experimental group, which used a manual with 360° images (refer to Table 3).

Table 3. Results of the Mann-Whitney test of the second PW to determine the impact of AR on students' performance in practical physics tasks

Assessment Criteria	Experimental Group (n = 54)			Control Group (n = 54)			Mann-Whitney Test U			
	M	SD	Mdn	M	SD	Mdn	U	Z	P	r
Practical performance	19.88	.25	20	16.78	1.58	16.90	60	–8.88	.000*	.85[a]
Report grade	17.63	1.08	18	12.7	1.22	13	31	–8.87	.000*	.84[a]
Time	10.59	1.92	10	4.41	3.17	4	162	–7.98	.000*	76[a]

Note: [a]large effect size, [b]medium effect size, [c]small effect size, *p < .001.

The data presented in Table 3 show significant differences in both practical performance and experiment report grades between students in the experimental group who incorporated the 360° image as an AR tool and those in the control group who followed traditional laboratory manuals. Students in the experimental group demonstrated superior performance, as indicated by a significant effect size (r > 0.80). Furthermore, the results indicate that students in the experimental group completed the experimental setups in significantly less time than their counterparts in the control group, also with a large effect size (r > 0.75).

Table 4 shows the results of the third PW, a combination of the two methods used in the previous manipulations. In the control group, the experiments were carried out using traditional laboratory manuals under the supervision of the instructor. In contrast, the experimental group used a manual supported by AR through the integration of QR codes and 360° images (refer to Table 4).

Table 4. Results of the Mann-Whitney test of the third PW to determine the impact of AR on students' performance in practical physics tasks

Assessment Criteria	Experimental Group (n = 54)			Control Group (n = 54)			Mann-Whitney Test U			
	M	SD	Mdn	M	SD	Mdn	U	Z	P	r
Practical performance	19.32	.78	20	14.03	1.24	13.85	.000	−9.12	.000*	.87[a]
Report grade	18.11	.88	18	12.94	1.25	13	8	−8.99	.000*	.86[a]
Time	4.52	3.12	3	13.28	3.03	8.90	96	−8.39	.000*	.80[a]

Note: [a]large effect size, [b]medium effect size, [c]small effect size, *p < .001.

The data in this table show that the group using the AR method based on QR codes and 360° images performed better than the control group in terms of practical performance evaluation criteria and reports with a large effect size (r > 0.80). In addition, this group demonstrated significantly higher temporal effectiveness than the control group, with a large effect size.

The tables above show the results of a Mann-Whitney test indicating significant differences in scores between the experimental and control groups on the practical performance and report scoring criteria at three separate measurement points (PW1, PW2, and PW3). The experimental group outperformed the control group in practical performance and report writing, with significant differences (p < 0.001) and a notable effect size (r > 0.80). In addition, students using AR completed experiments faster, leading to significant gains in time management. Overall, these results indicate that the use of AR via mobile devices had a significant effect on students' performance in electronics PW, improving their practical performance and the quality of their reports while reducing the time required to complete experiments. This suggests that AR can be an effective technology for improving student performance in this specific learning context. These results show that the use of AR in physics PW cannot only improve academic performance but also lead to tangible benefits in terms of time management.

4 DISCUSSION

The purpose of this study was to evaluate how the incorporation of AR through mobile devices affects students' performance on the physics PW. Mann-Whitney tests were used to compare the scores of students in the experimental group who used AR with those of students in the control group who completed the PW in the conventional way. The analysis focused on three main evaluation criteria: "practical performance," "report grade," and "time" spent performing the different manipulations at three different measurement points (PW1, PW2, and PW3). The students who worked with AR had higher scores in the performance of the different experiments as well as in the report compared to the control group. These results indicate that the use of AR in physics PW had a significant positive effect on students' performance in experimental manipulations as well as on the quality of their reports. The results also suggest that at each stage, the experimental and control groups showed significant differences in the time spent on the manipulations; the students in the experimental group completed the manipulations in significantly less time than the students in the control group. The differences observed were statistically significant and accompanied by considerable effect sizes (r). Our results are in accordance with those of other studies, such as [37], [38], [39], [40], [41], [42], [43], [44], [45], which have shown that AR-supported learning of physics PW via mobile devices has a positive impact on students' performance in physics PW. In the literature, several studied have found that educational technologies, including AR, can save learners time [46], [47], [48], while other studies found that students working with AR needed more time to complete the given task [49], [50]. In the case of our study, the use of AR on mobile devices allowed students in the experimental group to gain time in setting up experiments compared to students in the control group. Thus, based on the experimental results, the use of AR during physics PW significantly improved students' time efficiency compared to conventional methods. AR enabled rapid comprehension of instructions and experimental steps through real-time visual cues. It also facilitated the identification of requisite equipment and sustained student engagement by encouraging active exploration of the concepts. In summary, the use of AR made it easier to complete experimental tasks faster and more efficiently, thereby demonstrating its positive impact on practical learning in physics. This study found that the use of AR via mobile devices in physics PW significantly improved student performance while also promoting more efficient execution of practical tasks, accompanied by a reduction in the time required to perform experiments.

The use of AR via mobile devices with visual and auditory elements offered students a richer learning experience, allowing them to visualize the different experiments of each manipulation, the equipment used, and their operation in the circuit, as well as the different steps to be followed to perform them, which could improve their performance in the laboratories.

Augmented reality allows detailed visualization of circuits and their components, making experiments easier to understand. This technology allows students to spend more time interpreting results rather than handling equipment. In addition, quick access to additional information about each instrument via QR codes or 360° photos helped students gain a deeper understanding of how the instruments work, resulting in more accurate measurements and higher quality reports. This finding is consistent with other studies that have shown that guiding students in setting up experiments using AR can improve their results [35], [51].

Augmented reality had a positive impact on student performance due to several key factors. First, according to cognitive load theory, the integration of AR reduced students' cognitive load by providing additional sensory inputs synchronized with the learning materials [39]. This reduction in cognitive load facilitated the assimilation of knowledge and the retention of information during laboratory experiments. Based on the theory of selective attention, the presence of multiple channels of information presentation provided by AR influenced the way students directed their attention, helping them to focus on relevant educational content and reduce their cognitive load [52]. This combination of factors created an enriched learning environment that improved students' overall performance during physics practical. Taken together, it is clear that the use of AR not only stimulated student engagement but also led to tangible benefits in terms of efficiency and productivity during laboratory practical work.

5 CONCLUSION AND IMPLICATIONS

In conclusion, our study has shed significant light on the impact of using AR via mobile devices in the context of physics PW. Our results show that integrating AR into physics PW has a significant positive effect on students' experimental performance and the quality of their reports. These benefits are consistently observed across all students, highlighting the equalizing impact of this technology on learning.

The results of this study suggest that the use of AR via mobile devices can be an effective learning tool in physics, allowing students to perform different experiments in an interactive and immersive way. This can help students better understand these physical manipulations and phenomena and can provide additional support for students who are struggling. In addition to providing useful features for students, AR technology has reduced the instructor's workload by creating more interactive experiences, which can reduce the need for instructor supervision [37]. By using an AR application, students in the experimental group were able to complete their experiments in less time than the control group. They did not have to spend as much time preparing and conducting their experiments. This allowed them to spend more time discussing and interpreting the results obtained and to better understand the various physics experiments.

The approach of this study focuses on the use of mobile devices by students to access AR resources. This method is part of an educational trend that aims to use technologies that students already own to make learning more accessible, familiar, and cost-effective. The study also shows how the use of mobile devices can improve student performance in physics PW. It provides a model for integrating educational technology that merits further investigation for its potential to improve the teaching of physics PW. The results of the study highlight the positive impact of AR via mobile devices on student performance in physics labs, as well as the time taken to complete experiments. These findings suggest that integrating AR via mobile devices may be a promising strategy to significantly improve student performance in physics PW while optimizing the time efficiency of their experiments. It is fair to say that AR technology, when used correctly and adapted to learning needs, brings significant benefits to learners. It provides an effective teaching method that can improve student performance in physics PW. This technology is therefore seen as a valuable asset in physics PW to support learning and skill acquisition.

6 LIMITATIONS AND FUTURE STUDIES

The results of this study must be interpreted in light of certain limitations. Firstly, the sample size is relatively small, with 108 participants. It would be desirable to increase the sample size to confirm the results of the study. Secondly, the study does not take into account other factors that could influence student performance, such as student motivation or students' perceptions of AR. Additionally, the study is limited by the lack of control over extraneous variables that could influence student performance. These include individual differences in prior experience with augmented reality, differences in access to mobile technologies, and socio-economic differences. Furthermore, the limited duration of the study may not capture the long-term effects of AR use on student performance. Finally, the measurement of student performance may be subject to bias, particularly if it is based solely on one-off assessments rather than an ongoing, holistic assessment of learning. Based on the results of the study, the following recommendations can be made for future studies:

- Increase the sample size to confirm the results of the study;
- Conduct a longitudinal study to examine the impact of AR on student performance over a longer period; and
- Consider other factors that could influence student performance.

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