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Virtual Assistance System for Teaching Physics Experiments in University Students

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ABSTRACT

According to previous studies, it can be seen that education has been facing new challenges to improve the quality of student teaching by achieving a better interpretation of the conceptual part and the experimental part as they are directly related, improving learning in natural science courses that require students to carry out experiments in laboratories to consolidate their knowledge. The problem raised in this research is that the teaching of the theoretical part is more important than the experimental part with respect to the Physics course due to the little time students have in the laboratories, as well as the limited space that does not allow them to freely carry out experiments in laboratories as poor infrastructure, resulting disadvantageous for students by not demonstrating the hypotheses raised from the theory that would allow them to consolidate their knowledge. The aim of this research work is to develop a virtual assistance system for teaching physics experiments to university students with a high level of reality in order to improve the student's experimental practice, taking advantage of a new form of centralised teaching that prioritises the student's time and space through a dynamic interface. The methodology used for this research is based on a client-server model, a TCP/IP data protocol that allows the computer to send and receive data, graphical features of the operating system with the Microsoft Windows platform for interaction with the virtual laboratory without time restriction. According to the tests carried out, it was observed that the virtual assistance system was performed efficiently by detailing the tests of its corresponding function with an efficiency of 95.14%, which is a high value for a virtual laboratory system that allows experimental processes to be carried out. It was concluded that this system presents a dynamic interaction to perform experiments in the virtual physics laboratory with the appropriate materials for better learning.

1. Introduction

Education in the 21st century faces new competencies due to the constant changes that society has to García *et al.,* [1], so that higher education centres have the need to train students with solid

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knowledge capable of sustaining various situations with natural behaviours that occur in society through Natural Sciences to López *et al.,* [2]. Given this, there is a conventional method of teaching Natural Sciences, where the conceptual part stands out over the experimental part to Álvarez *et al.,* [3], causing the non-validation of previous hypotheses that are developed in subsequent concepts to Roda [4], which are accessed through observations and experiences, preventing the student implements the experimental practices that would consolidate their knowledge in the proposed investigation to Kerem *et al.,* [5].

The experimental part transcends from observation, allowing to manipulate the variables that intervene in the studies of natural phenomena through a previous data analysis to Eldia *et al.,* [6], for this reason, Physics is applied to understand each aspect of nature and try to order it in based on experiments to Alsaleh *et al.,* [7], commonly carried out in a laboratory to introduce or eliminate variables that influence the behaviour of matter, such as its movement along with its energy and force to Zhang *et al.,* [8], likewise, the application of Physics has allowed an important development in daily life from people by his various fields of study who have related him to almost everything in some way or another to Gotte *et al.,* [9].

Therefore, the experimental part is fundamental for the teaching of Physics by consolidating itself as an indispensable strategy in studying natural phenomena to Zhang *et al.,* [10], demonstrating seriousness, validity and rigor regarding the verification of hypotheses to Hwang *et al.,* [11]. But the truth is that, as the experiments require experimental means to Genkov *et al.,* [12], contents and a series of steps under fixed conditions, it limits university students to carry out the instructions that the teacher gives them due to the little time they have in the laboratories, making them thoughtless by to Tapia *et al.,* [13] not understand the objective of the experiments, likewise, over the years the experimental part has become a rigorous process for the student to build their knowledge base and constituting their truthful mechanism for science to Scherer [14], for this reason, it is necessary to Melo *et al.,* [15] develop a virtual assistance system that allows the student to carry out physics experiments without time restrictions.

This research aims to highlight the importance of experimenting in Physics teaching in all educational centres at a national level in order to test the theory and check whether the hypothesis put forward about the behaviour of some matter is valid by taking advantage of the laboratory equipment that will allow us to carry out the experimentation. For this reason, it is important to implement this system to experiment in Physics laboratories without limitations in order to apply it in daily life and relating it to other subjects of study that are fundamental.

The objective of this research is to develop a virtual assistance system for teaching physics experiments in university students with a high level of reality in order to improve the experimental practice in the student, taking advantage of a new form of centralized teaching that prioritizes time and student space through a dynamic interface. Its development is based on a client-server model, as well as the TCP/IP data protocol that allows computers to send and receive data, it also uses the graphic characteristics of the operating system with the Microsoft Windows platform for real student interaction. within the virtual laboratory without time restriction to improve the teaching capacity.

In section II, the literature review is carried out by relating it to previous research. In section III, the methodology of the system is carried out by detailing the parts of the block diagram. In section IV, the development of the student interface for virtual experimentation is carried out. In section V, the results achieved by the system are made. In section VI, the discussion of the system is carried out. In section VII, the conclusion and recommendation are made.

2. Literature reviewed

Experimentation in the field of physics is essential to understand each behaviour of matter based on observations and experiences, it being necessary for the student to develop these skills within virtual laboratories with the corresponding time through systems. For example: In Tripicchio *et al.,* [16], the researchers mention that the platforms developed to carry out virtual experiments should give students the facilities to understand and manage the study variables when they are analysed, as well as the ability to carry out the experiments in real time for an adequate interaction between the platform and the student for a better result, therefore, they decided to develop a virtual laboratory system based on the performance of natural science experiments. The researchers' procedure is based on several modules in scripting language compiled with bytecode and running in a virtual machine, so that the virtual laboratory can be accessed from a web page when the program is executed correctly. As a result, they presented an 88,74% efficiency in the development of the virtual platform, reaching the conclusion that this proposed system uses an improved platform with improved interaction for student learning.

In Schuss *et al.,* [17], the researchers mention that the teaching of Physics course is an instrument that serves as a basis for students to learn about natural phenomena, as well as the behaviour of matter according to the force or heat that can be applied to it, which is why remote laboratories are important for the student's lifelong learning, therefore, they decided to develop a system for teaching instrumentation and measurement in remote laboratories. The procedure of the researchers is based on developing an instrument based on physical circuits with the aim that students can access remotely to perform their laboratories through the internet to experience the corresponding subject by the teacher through this dynamic interface that contributes to the constant learning of the student. As a result, they presented 74,96% efficiency in the interaction of the student with the virtual laboratory, demonstrating that it is possible to overcome the form of face-to-face laboratory with the virtual ones for the student, reaching the conclusion that this proposed system shows a new way for the good of the student with respect to the experimentation of the Physics course.

In Koun-tem *et al.,* [18], the researchers mention that the student's learning must be related to the application of their knowledge in the laboratories, allowing the consolidation of what they have learned through practice, but the practice time in the laboratories is very short for the student, for Therefore, they decided to develop a web-based virtual laboratory learning system for elementary schools. The researchers' procedure is based on developing a virtual laboratory where students can freely handle the virtual tools and can observe the experimental process that is proposed, demonstrating the theory that was previously raised through experimental research in the virtual laboratory. As a result, they presented a 75,45% efficiency in the student's interaction with the virtual laboratory, reaching the conclusion that this proposed system shows a viability so that the student can carry out the virtual laboratories without problems.

In Sus *et al.,* [19], the researchers mention that the development of virtual laboratories is relevant to reinforce student learning, putting their knowledge into practice, specifically in the field of physics where experimentation is necessarily necessary to observe the behaviour of matter in a certain time, being able to perform real measurements in an interactive space with automatic methods, therefore, they decided to develop an automatic virtual laboratory system for the assistance of students in natural sciences. The researchers' procedure is based on diversifying the virtual laboratory environment at each stage, allowing the student to control and evaluate the experimentation carried out in each work, likewise, the virtual laboratory tools allow the student to collect the experimentation data in time real for your notes. As a result, they presented an 89,47%

efficiency in the dynamics of the virtual platform for the student, reaching the conclusion that this proposed system allows the student to carry out experimental work with various virtual instruments for a better evaluation.

In EVSTATIEV *et al.,* [20], the researchers mention that experimentation plays an important role in the practice of natural sciences, since to a large extent it allows theory to be developed in practice through a laboratory, but in the midst of a pandemic access to closed spaces was prohibited for fear of infections, causing many students not to carry out their corresponding experimentation, therefore, they decided to develop a web system for virtual laboratories applied to electronic engineering students. The researchers' procedure is based on developing a virtual laboratory designed with feasible equipment for engineering students, being able to realistically experiment within the virtual platform that offers a new experience unlike conventional laboratories that offer a short time in the practice. As a result, they presented 90,96% efficiency in the development of the virtual platform, reaching the conclusion that this proposed system facilitates its operation for the student with the terms of the virtual laboratory.

3. Methodology

The methodology developed for this system allows the student to carry out experimental work in Physics through virtual assistance, managing various tools that will facilitate the student's understanding of topics such as electromagnetism, modern physics and mechanics to observe the experimental processes and obtain the expected data, as well as if it were a face-to-face laboratory. Figure 1 shows the block diagram of the system.

According to the diagram shown, the virtual assistance system is based on a client-server model by establishing communication through the TCP/IP data protocol programmed in Winsock, in the same way, the server is made up of a network interface that is in charge of to assist the students, as well as to feed back the results to resend it to the students, the server also consists of a database that stores various information such as experimental data, student information, and template information and data reports for student authentication. Similarly, the client is represented by the student and is made up of an experimental model and a report module.

Since the system is based on a client-server model, the accuracy of the communication protocol is critical in complementing the function of the server's network interface. Communication is established by the client by sending a request message to the server, the server acknowledges the request message and binds it into a local port and replies compressed after handling the large size of the report. Likewise, the templates and data reports use the Microsoft Word document for ease of use, allowing the student to consult or check the reports.

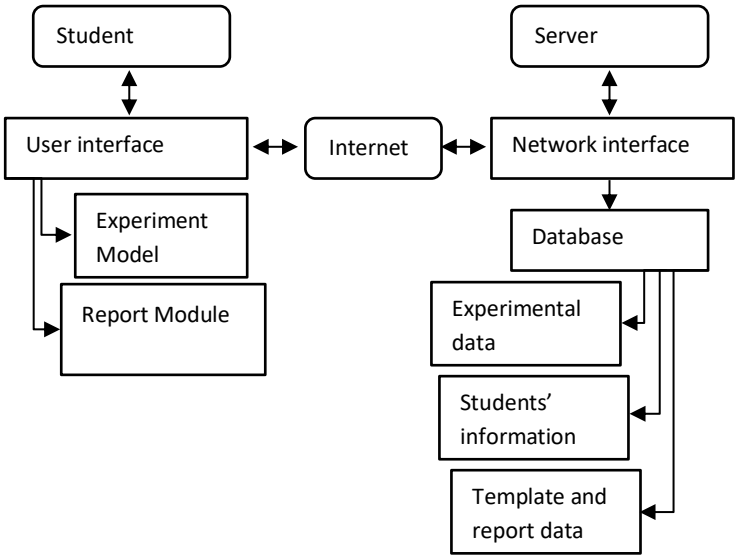

Fig. 1. Block diagram of the virtual assistance system

4. Operation of the Virtual Experimentation Interface

The virtual assistance system for teaching physics experiments applies a user interface that realistically simulates the experiments carried out by the students when handling the laboratory instruments and acquiring the expected data throughout the experimentation process, as shown in Figure 2. With its raised design and its realism in virtual interaction, they make the student quickly understand the operations of the instruments to apply the experimentation methods in a more impressive way, improving their teaching of experiments from the computer.

Fig. 2. Virtual assistance system for Physics experiments

The Physics experiments through virtual assistance were developed on the Microsoft Windows platform due to the ease of student interaction when entering the virtual laboratory, showing them a virtual window with a Physics laboratory design that, when right-clicking the mouse on the image, the student will see a list of tools where they can choose the materials, they need according to the topic they need to experiment in the laboratory. These materials are indicated as images, texts and animation that after interpreting them in detail, the student can carry out the experiment by dragging the materials and placing them on the table, likewise, by double-clicking on the materials, their configuration can be edited to carry out the measurements. precisely. In the same way, this interaction with virtual assistance allows the student to perform laboratory experiments realistically

on the computer in a centralized way, since virtual assistance can only be used on a single computer per student.

5. Results

The results obtained from the system tests confirm the successful operation of the virtual laboratory to carry out experimental Physics work on university students using a computer in a real way, showing a correct list of tools that allows the student to elaborate on the materials required for experimentation in the virtual laboratory in a new and precise way when configuring each material.

The development of this virtual assistance system was carried out in an efficient manner, and when the corresponding performance tests were carried out, it was determined that it operates with an efficiency of 95,14%, which is high efficiency because it is a virtual laboratory system that allows the student to carry out the experimental processes and observe each step-in detail in order to carry out the corresponding measurements. Table 1 shows the characteristics of the virtual assistance system for teaching physics experiments.

Table 1
Characteristics of the virtual assistance system

Analysis of the respiratory system	
Implemented	Students
Virtual platform	Microsoft Windows
Device	Computer
Experimentation time	No time limit
Efficiency	95,14%

The result obtained by this system contributes to student learning by giving a new approach to virtual experimentation for the Physics course, with more time and better real interaction with the laboratory materials, unlike the face-to-face laboratory that has a time limit. to get things done in the lab.

This system shows in detail various laboratory tools that allow the student to carry out virtual experiments of the courses detailed above, being able to observe each part of the experimental process and configure the materials according to the expected results instantly.

From the result obtained, it is determined that its implementation in the various institutions will allow students to improve the experimental part in the Physics course, knowing that today it is essential that the student demonstrate each process to have a better support, likewise, this system makes students become more active in solving the problem with time and space.

6. Discussion

Virtual laboratories allow a new interaction of the student with the developed interface so that they can observe the behaviour of matter in a certain time and space, therefore, the proposed methodology has differences in its development with other existing systems, for example, research carried out by Tripicchio *et al.,* [16], where the researchers decided to implement a virtual laboratory system based on carrying out natural science experiments. Obtaining as a result an efficiency of 88,74%, but this system proposed by the authors does not control the progress of the

students, likewise, it does not provide virtual materials for the various topics that exist in the field of physics so that the student can handle the corresponding variables.

The research carried out by Schuss *et al.,* [17], where the researchers decided to develop a system for teaching instrumentation and measurement in remote laboratories. The result was an efficiency of 74.96%, but since this system is completely network-based, student interaction can be complicated if their network is disconnected or if the network is unstable.

The research carried out by Koun-tem *et al.,* [18], where the researchers decided to implement a learning system in a web-based virtual laboratory for primary schools. Obtaining as a result an efficiency of 75,45%, but this system proposed by the authors is limited with the virtual laboratory tools, causing the student to only be able to use this virtual tool for two specific topics in physics.

The research carried out by Sus *et al.,* [19], where the researchers decided to implement an automatic virtual laboratory system for the assistance of students in natural sciences. Obtaining as a result an efficiency of 89,47%, but this system proposed by the authors was limited to carrying out the corresponding tests with the students, experiencing the web platform among them, likewise, the time proposed in practice is less with the user interaction.

The research carried out by EVSTATIEV *et al.,* [20], where the researchers decided to launch a web system for virtual laboratories applied to electronic engineering students. Obtaining as a result an efficiency of 90,96%, but this system limits the student to create electronic circuits within the virtual platform, so they cannot experience most Physics topics knowing that this system is applied to students. university students. Next, a comparison was made visualized in Table 2 of this system (a) with our system (b).

Table 2
Comparison between two virtual assistance systems using different methodologies

	a	b
Device	Computer	Computer
Experimentation	Physics course	Physics course
Platform	Python	Microsoft Windows
Experimentation time	Limited time	Unlimited time
Accuracy	90,96%	95,14%

Continuing with the comparison with EVSTATIEV *et al.,* [20], Figure 3 shows the virtual assistance systems for Physics experiments where different development platforms can be seen that make the virtual laboratory present similar tools to the on-site laboratories, likewise, in system

i. an interface with few laboratory tools is visualized, while in our proposed system
ii. an interface with a greater number of laboratory tools is visualized so that the student can simulate according to the required topic.

(a) (b)

Fig. 3. (a) Basic virtual system (b) Virtual assistance system for physics experiments

7. Conclusion and Recommendation

From the system we can conclude that its operation with the students is very good, with dynamic interaction for the elaboration of experiments in the virtual laboratory with suitable materials for the exact measurement of the experimental values. This dynamic interaction allows the student to have a greater facility for experimental practice in order to apply their theoretical knowledge.

From the system we can conclude that its contribution in the field of education is relevant for students, likewise, its management to carry out virtual Physics experiments is feasible so that they can develop it at any time from their computer. There is no time limit to practice it virtually without problems.

From the system we can conclude that the student experience is safe and allows interaction with more time without problems, since being a virtual laboratory allows the student to access any space. In the same way, the student will have the same results obtained in the face-to-face laboratories to prove that this system is reliable.

From the system we can conclude that its development has differences with respect to other virtual systems, highlighting its unique methodology applied to develop a dynamic interface so that the student can perform the experiments in the same way as in their study centre.

As future work, a server dedicated to real-time interaction between students will be added to develop group work in the virtual laboratory, in such a way that they share their experimental knowledge.

It is recommended that each student develop the experimental part from their own computer to avoid data conflicts with the server, being able to write down the measurement data in the experimental part.

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