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A Smart Learning Management System for Virtual Labs

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Abstract: Information and Communication Technology (ICT) has provided unprecedented opportunities to enhance the quality of life over the past few decades. It has not only augmented the efficacy of telecommunication but also facilitated lifelong teaching and learning. ICT played a remarkable role in assisting students during the COVID-19 pandemic. Since the outbreak of the pandemic, schools and colleges have been closed to prevent its lethal impact. In order to facilitate teaching-learning during the pandemic, the entire educational system was shifted to an online mode of knowledge dissemination. In the online mode, both students and teachers encountered some difficulties. During lockdowns, mobile devices, such as smartphones and tablets, were used to conduct online experiments via virtual platforms. Despite this, a comprehensive Learning Management System (LMS) was required to fill the gap created by the lack of proximity in a typical classroom. A LMS not only makes online learning possible, but also helps students gain practical experience and allows teachers to evaluate them.

In this paper, an Android-based LMS is proposed to assist students perform physics experiments virtually on smart devices. The proposed system is an inexpensive, hands-on solution that is easy to install on smartphones and tablets. The main objective of the proposed system is to provide teachers with a comprehensive way of managing teaching-learning and evaluating the knowledge of concepts. Though the proposed system is designed for the physics lab, it can be expanded and adapted to other subject areas. The system is not intended to replace the current education system, but to supplement it by fostering and testing innovative ideas and solutions for effective learning.

Keywords: Android operating system, online mode, teaching-learning, virtual lab.

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1. Introduction

Education is essential for a nation's overall socioeconomic development. Over the past few decades, scholars and academics from around the world have shown a growing interest in the field of Information and Communication Technologies (ICT). This has changed the face of education throughout the world from a traditional classroom to a high-tech, contemporary facility for imparting knowledge (Murthi & Yoo, 2021). As a result, the quality of teaching and learning in schools and colleges has significantly increased, with improved outcomes for students who utilise these technological resources. With the advent of ICTs, the concept of blended learning, which combines traditional and technology-based programmes, has paved the way for maximum flexibility and variability in content delivery (Kintu et al., 2017; Amutha, 2020).

Traditional education has suffered from the pandemic of COVID-19. Students and teachers were required to maintain physical separation to prevent the spread of disease. Consequently, online knowledge transmission replaced the traditional teaching-learning process during the outbreak. Although e-learning was a viable option for acquiring theoretical concepts, laboratory experiments were challenging to conduct, especially during the pandemic lockdown.

Experiments are a crucial component of any course that aims to help students comprehend the practical application of concepts. Laboratory experiments also enable correlations between theoretical concepts and their applications in practice. The need for hands-on experiments during the pandemic necessitated the use of virtual platforms rather than a physical lab. Virtual Labs (VL) have emerged as a promising alternative for maintaining social distance and allowing students to conduct lab experiments on their smartphones and tablets during lockdowns. Even as the world attempts to return to normal classroom instruction and recovers from the devastating effects of the pandemic, VL continues to supplement the conventional education system. It facilitates hands-on experimentation in situations lacking a robust infrastructure. VL provides students with essential information, knowledge, and practical experience by utilizing ICT tools.

VL makes it easy for students to utilise cutting-edge technologies and permits them to conduct a variety of experiments regardless of their location or time of day. Virtual laboratories employ a variety of teaching methods and e-learning technologies to facilitate students' comprehension of abstract ideas. These include the use of visuals, active learning, recall-based learning, gamification, and narratives. In addition, they provide a collaborative and risk-free learning environment in which students can conduct experiments and hone their skills.

The Learning Management System (LMS) is a web-based technology or software application that provides pedagogical training. A LMS facilitates coordinating and managing effective learning using VL. It provides a platform for students and teachers to organise, implement, and evaluate a specific learning process. VLs with LMS integration can educate all students, beginners, and independent learners. LMSs facilitate blended learning by combining traditional classroom teaching techniques with advanced online tools for concept reinforcement. Teachers can use a LMS to assign work, share knowledge, and submit grades, while students can access content and communicate through forums and social features. Universities have begun to offer online courses, and to promote and deliver these online programs to students, a LMS is required. Students have access to online courses from anywhere and at any time using a LMS.

This paper proposes a LMS to simulate practical laboratory experiments using smart devices in the same manner as in a physical lab. The system is intended to simulate experiments in various branches of physics, but it is easily extendable to other academic disciplines. The primary objective of this work is to develop a LMS to support VL. The proposed system can facilitate improved student-teacher communication and collaboration.

Two modes of operation are supported by the proposed system: one for students and the other for teachers. The system's student module provides detailed information about the experiments as well as step-by-step instructions for conducting them. It also supports the tutorial section, which guides students through their experiments. In addition, the system includes a quiz section where students can assess their conceptual understanding. In addition, a distinct Teacher module is supported by the system to assist teachers in creating questionnaires for students' evaluation and reporting the results to both students and teachers.

The primary goals of the proposed LMS are outlined below:

1. The system aids students in combating current and future pandemics by allowing them to conduct physics experiments remotely using smart devices.

2. In the conventional educational system, when there is a lack of infrastructure to provide practical experience, it also makes it easier to understand the concept.

3. Separate modules are provided for students and teachers to conduct experiments and evaluate student work efficiently.

4. Students are provided with step-by-step instructions to conduct experiments without having to memorize the procedure.

5. The system has two modes of operation: built-in mode, which uses the system's default settings, and custom mode, which allows students to set parameters for experimentation. The Built-in mode of the LMS is designed for novices, while the Custom mode is suitable for more advanced learning.

6. The system also allows students to record observations and facilitates a high level of teacher-student interaction.

The organization of the paper is as follows: Section II reports related works from the literature, while Section III describes the methodology used to design and implement the LMS for the Virtual Physics Laboratory. Section IV presents the investigational study to implement the proposed LMS. The proposed system is validated and tested by students as well as teachers, and their feedback and the experimental results are presented in Section VI. The proposed LMS is compared to existing systems in section VI, and the paper is concluded in section VII.

2. Literature Survey

Hands-on is very important in understanding any subject deeply and thoroughly. Experimenting in a virtual environment has become common in the context of the COVID-19 pandemic. Due to limitations in adhering to social distancing norms, physical hands-on testing has suffered a major setback. In such a case, virtual labs appear to be a lifeline.

Many virtual labs are currently available on Android devices. Physics-Lab (TurtleSim,2022) and Physics Virtual Lab (Abbasi, 2021) offer a virtual environment for conducting physics experiments, but they cannot assess learners' conceptual knowledge. There are no provisions for customising the experiment in the Physic Virtual system (Abbasi, 2021), and there is no assistance in running the experiment. Aside from the aforementioned Android apps, there are web applications, such as IIT-Kanpur Virtual-Labs (Akhtar & Srivastava), that provide a virtual environment for web experimentation. In this virtual lab, there is no way to customise the experiment to assess the learner's knowledge. Olabs (www.olabs.edu.in), Virtual Labs by MoE (https://www.vlab.co.in/), Virtual Labs-IIT Bombay (http://vlabs.iitb.ac.in/vlab/), Amrita Vishwa Vidyapeetham's virtual lab (https://vlab.amrita.edu/) are used to provide a virtual environment for experiments. These, on the other hand, don't have any student-specific features for running experiments or letting the teacher update or change the quiz questionnaire.

Many research papers have also been published in virtual labs. Bogusevschi et al. describe the computer-based VR-VL application on Water Cycle in Nature for teaching Physics concepts (Bogusevschi et al.,2020). The findings of a case study conducted in a secondary school to assess the usability of the VR-VL application were presented. An Android application - Physics Virtual Lab, was proposed by Erfan et al. that focused on enhancing the understanding of concepts related to light and optics (Erfan et al., 2020). Descriptive quantitative research on the formation of images using lenses and mirrors was conducted. Kiv et al. proposed an Augmented Reality (AR) based android Physics application that enables virtual laboratory work. (Kiv et al., 2021). To ensure a higher level of interaction between teachers and students, the use of AR for physics is proposed. The visualization tool presented could enhance the attention, understanding, and motivation of students. An Android application named ViPhyLab is developed that focused mainly on Rotational Dynamics (Arista & Kuswanto, 2018). Data analysis is performed to prove that the ViPhyLab application could improve students' learning and conceptual understanding. Using AR, the worksheets for students were developed through 3D simulation. (Sumardani et al., 2020). The product was tested for eligibility by Media, Material, and Learning experts. The results indicated that the augmented physics lab was feasible for the physics practicum on the magnetic field. An Android-based physics learning media on the topics of Impulse-Momentum (Wirjawan et al., 2020) was developed and the quality of the application was determined through expert appraisal, teacher evaluation, and student feedback. The work used the developmental research method to define, design, develop, and disseminate the concept. Kapilan et al. highlighted the importance of VL in teaching mechanical engineering (Kapilan et al., 2021). They conducted Faculty Development Program (FDP) for faculty and developed the fluid mechanics VL for the students. The developed VL proved beneficial for both teachers and students. The research was conducted to show the simulation of Physics Education Technology (PhET) as a virtual laboratory for learning waves and sounds (Gunawan et al., 2018).

The results obtained were useful for both the cognitive aspect of development and experimentation using a science laboratory.

Experimentation plays a very significant role in the teaching and learning process. It is crucial for a thorough understanding of concepts and their real-world applications. A LMS may assist students in carrying out experiments while adhering to the obligations of social distancing in the event of a pandemic. Furthermore, it assists teachers in creating a quiz questionnaire for assessing the practical knowledge of students.

3. Research Methodology

The emergence of the COVID-19 pandemic has resulted in the suspension of numerous global activities, such as regular teaching and learning. Both educational activities and laboratory experiments have undergone profound changes. Traditional educational methods cannot be used to facilitate a teaching-learning process where spatial separation is the primary requirement. However, laboratory experiments help students grasp theoretical concepts by putting them into practice. Consequently, the significance of conducting laboratory experiments cannot be discounted. During the peak of the pandemic, all lab activities were conducted remotely or virtually to provide students with the necessary exposure to theoretical concepts. The application of ICT tools has enabled online teaching and learning.

The Learning Management System (LMS) proposed in this study provides students and teachers with an environment in which students can conduct experiments and teachers can evaluate their performance using Android devices. The system provides separate logins for the teachers and the students. Before conducting the experiment, the student can review the concepts necessary to perform the experiment.

The system provides two modes of operation: the Built-in mode and the Customized mode. The student may choose and employ any mode of operation according to his level of understanding in a particular experiment. Students' performance can be evaluated using quizzes. Both the teacher and the student have access to the student's quiz scores, which can be generated using the system's teacher module. The proposed system aims to provide an all-inclusive package for conceptual and practical knowledge acquisition, testing, and evaluation.

A. Overview of the Proposed system

The proposed LMS is developed using the Android Studio Integrated Development Environment (IDE). The detailed flowchart showing the overall approach is shown in Fig. 1.

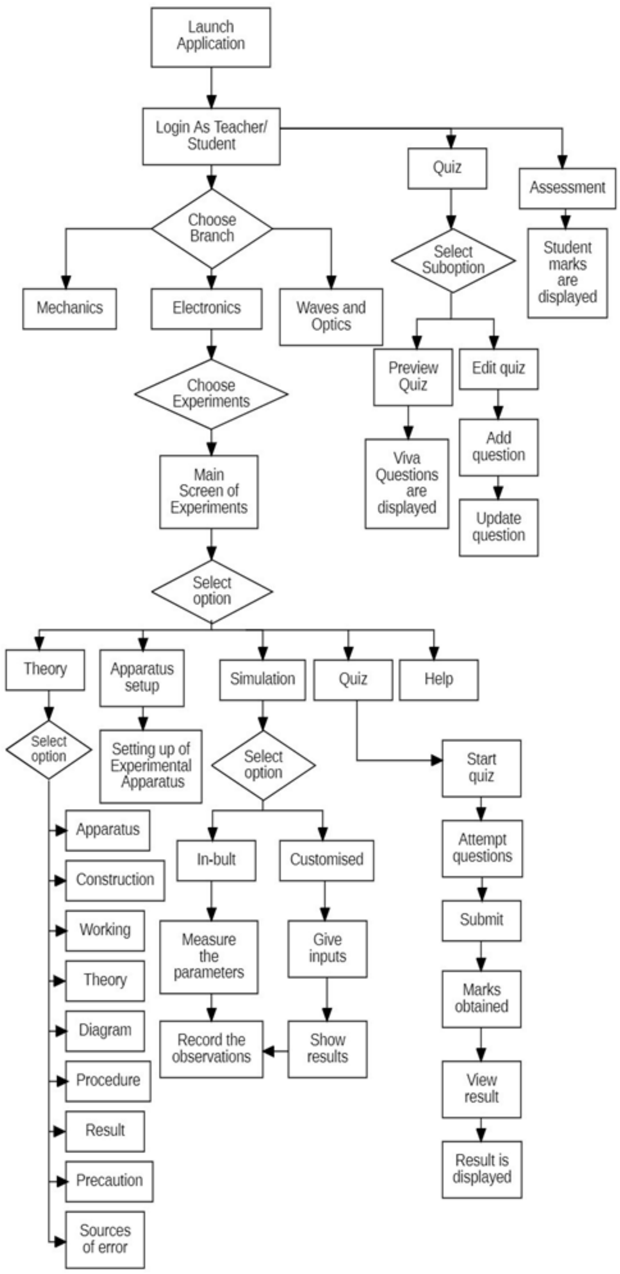

Fig. 1 : Flowchart of the working of the Proposed Learning Management System

The LMS is primarily designed to support a physics laboratory course that expands students' understanding of mechanics. The student should be able to demonstrate the following Course Learning Outcomes (CLOs) upon completion of the course:

1. To understand the fundamental laws and concepts of Physics.

2. To conduct elementary experiments in mechanics and familiarise students with a variety of measuring instruments.

3. To gain experience in conducting and troubleshooting one's investigations while learning the importance of precise measurement.

4. To acquire the skills necessary to analyse and comprehend data.

5. To utilize the acquired knowledge and skills to solve real-world problems.

6. To perform laboratory work independently and collaboratively in groups.

Searle's apparatus is used to demonstrate the proposed system for computing the Young's modulus of elasticity. Using the proposed LMS, the expected Program Learning Outcomes (PLOs) are as follows:

1. Learn the fundamentals of elasticity through the study of the Young Modulus.

2. Understand the relationships between stress, strain, and linear elasticity (Hooke's law).

3. Provide a hands-on learning experience in measuring stress, strain, and modulus of elasticity.

4. Determine the effect of variations in the wire's radius, length, and material on the modulus of elasticity.

5. Quantify knowledge of the scientific principles underlying the experiments using an evaluation system.

6. Promote interactive learning.

Student learning objectives, or PLOs, are the observable or measurable outcomes of a learning session. They let both teachers and students know what to expect when a program is finished. CLOs and PLOs are often put together to figure out if the main goals of the program have been met.

The planned LMS has two separate modules, one for teachers and the other for students, which are briefly explained below.

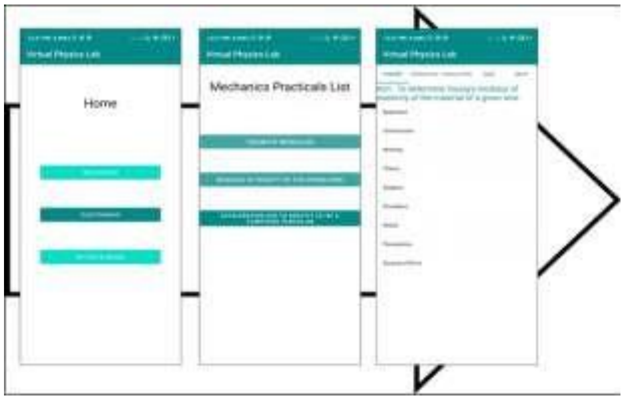

Fig. 2: Process flow of the designed system under the student module

1. Student module

Students are directed to the home page using this module, as shown in Fig. 2. On the system's home page, three clickable buttons are provided to select the branch of "PHYSICS" under which the student intends to conduct the experiments. The Branch options include Mechanics, Electronics, and Optics & Waves, as shown in Fig. 2. After selecting a branch, the home screen displays a list of available experiments within that branch.

Fig. 3. Application screen of the selected experiment of Young's Modulus and other sub-screens under the main screen

Using Searles' apparatus, the proposed system demonstrated the calculation of Young's Modulus of Elasticity. The main screen of the experiment is shown in Fig. 3. The system has clickable tabs for Aim, Apparatus, Theory, Procedure, Formulas, Precautions, Sources of error, and Result of the selected experiment. The tabs will allow the student to obtain comprehensive information about the selected option. A Help tab provides the user with detailed instructions on how to conduct the experiment.

The prime objective of the proposed work is to facilitate hands-on training for Physics experiments. The student can configure the apparatus using the system's drag-and-drop functionality. The apparatus setup screen of the system is divided into three sections: the left panel, the top panel, and the bottom panel. The left panel consists of the labels of the instruments or apparatuses necessary for the experiment setup. When a student selects a label, the corresponding thumbnail appears on the screen and can be dragged and dropped onto the bottom panel to complete the experimental setup, as shown in Fig. 4. After the final setup, the experiment is performed by clicking on the Simulation tab and following the steps outlined in the Procedure tab.

Under the Simulation tab, the student has two options for experimenting: Built-in mode and Customized mode, which are described in detail in the following subsections.

A. Built-in Mode

A Built-in simulation mode is available in the proposed system to support novice students who may not be familiar with the experiment. For experimentation, the parameter default values have been used. The drop-down menu located in the top right corner of the screen, as shown in Fig. 5, is used by the student to select the pre-defined input values for simulating the experiment.

Fig. 4 : Screenshots of a complete experimental setup for computing Young's Modulus of elasticity using Searles 'apparatus

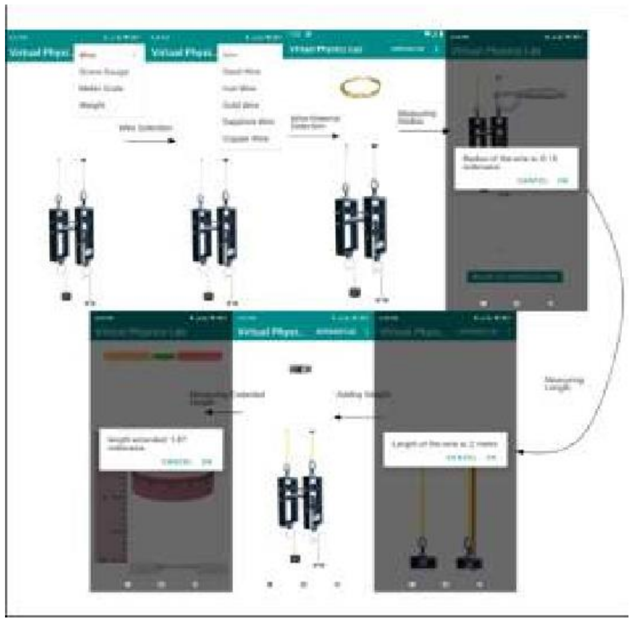

Fig. 5: Screenshots for computation of Young's Modulus of elasticity using Searles 'apparatus under the Built-in simulation tab

B. Customized Mode

This mode can be used to study the experiment in greater detail. The students can hone their creative and logical abilities while exploring the values of the input parameters.

2. Teacher module

In this mode of operation, teachers can create quizzes to evaluate student performance. After logging into the system, the teacher will specify the intended semester and course for the quiz. The teacher is provided with the Preview Quiz and Edit Quiz options, as shown in Fig. 6. The Preview Quiz option enables the teacher to review the questionnaire before sending it to the students, while the Edit Quiz option enables him to modify or update the quiz questionnaire, as shown in Fig. 7.

The teacher may include additional information on the questionnaire, such as the total number of questions, marks, time etc.

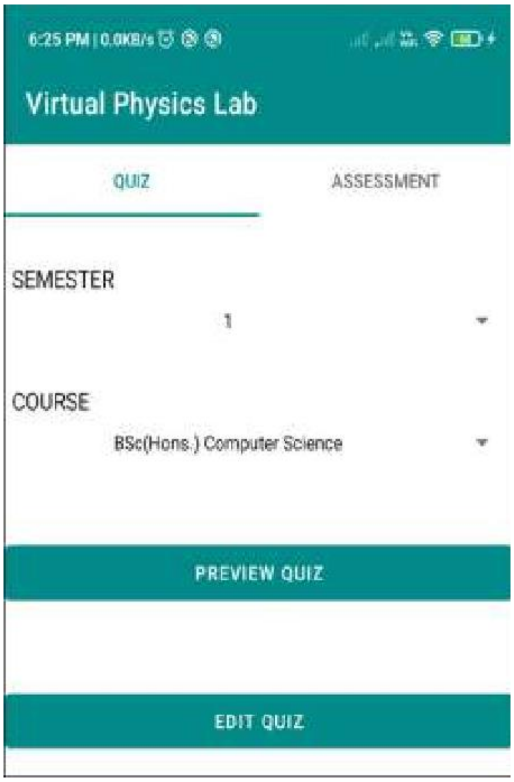

Fig. 6: Application screen for preview and edit quiz under the Quiz tab

Fig. 7 : Application screen for teachers for updating or editing Quiz questionnaire under the Quiz tab

After completing the questionnaire, the teacher will be required to press the Submit button.

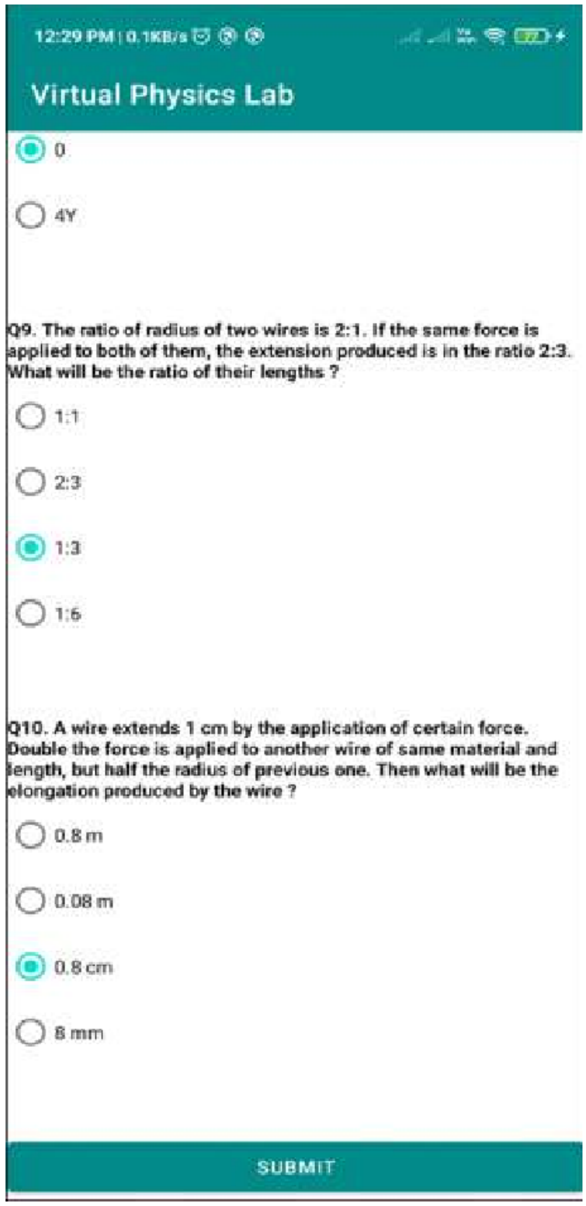

Fig 8 : Application screen for teacher user for viewing the quiz questionnaire with correct answer option under Quiz tab

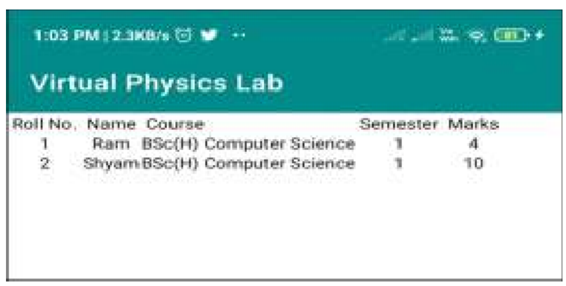

Fig 9 : Application screen for teachers for viewing the result of the quiz

When the Preview Quiz option is chosen, a list of all questions set by the teacher is displayed, as depicted in Fig. 8. As depicted in Fig. 9, the teacher has access to the quiz scores of each student via the Assessment tab. The teacher can view a student's marks by clicking the View Marks button on the tab.

The LMS proposed in this work is anticipated to provide a comprehensive suite for conducting experiments virtually without physically visiting a laboratory. The system is intended to enhance the teaching, learning, and evaluation of the concepts taught in theory and may serve as an intelligent LMS for virtual experimentation and student evaluation.

4. Implementation of the Proposed LMS

The proposed system is demonstrated and validated using a well-known physics experiment: computing Young's modulus of elasticity using Searles' apparatus.

The student can choose different wire materials to set up the apparatus for determining Young's Modulus in the Built-in mode. After selecting the wire, the meter scale displays a fixed length of the wire, the screw gauge displays a constant radius value, and the experiments are carried out with fixed weights. Predefined values are assigned to various parameters. The parameters pre-assume the values shown in Fig. 10 when the student clicks on the right corner of the menu.

- Wire option: A submenu is displayed where the student can select any of the given types of wire for the apparatus set-up, and the predefined values associated with that material are displayed for the computation of the result.
- Screw Gauge option: A thumbnail for the Screw Gauge appears on the screen above the Searle's-apparatus setup, and upon dragging it down to the setup, another screen or window pops up and the predefined radius value of the wire appears.
- Meter scale: A thumbnail for Meter Scale appears on the window above Searle's apparatus, which can be dragged down to measure the length of the wire. A fixed length of wire is taken for the Built-in mode.
- Weight option: A pull-down menu appears with the different values of weights that can be selected by the student and can be dragged down for the apparatus set-up.

Fig 10 : Various screens for explaining the simulation of Searle's apparatus under Customized simulation tab

A new window opens up where the user can adjust the mercury level of Searle's apparatus using the spherometer to find out the change in length of the wire after applying the weights. The student can note down the reading of the spherometer for calculating the extended length of the wire for computing Young's modulus of elasticity following the formula:

$Y=mgl/\pi r2L$

where m = Weight applied

g = Acceleration due to the gravity of Earth (9.8m/s2)

l = Length of the wire extended

π = 3.14 or 22/7

r = Radius of the wire

L= Original length of the wire

Using the customized mode of the system, wires of different material weights, lengths, and radii can be selected. The student can fill in the three placeholders for weight, length, and radius of the wire for experimenting as shown in Fig. 11.

A Show Result button is provided on the screen, which a student can press to obtain the final result. This button is enabled only after all the required values are entered; it remains disabled otherwise. On pressing the Show Result button, the extension of the wire and the value of the Young's Modulus of the wire will be displayed on the screen. The student can note down these results.

Fig. 11 : Application screen for feeding customized data for Searles 'apparatus set up for determining Young's modulus under Customized simulation tab

In the proposed LMS system, there is a provision for performance evaluation via quizzes. The student's name, roll number, semester, and course name need to be entered to enable the Start Quiz button on the screen, as depicted in Fig.12.

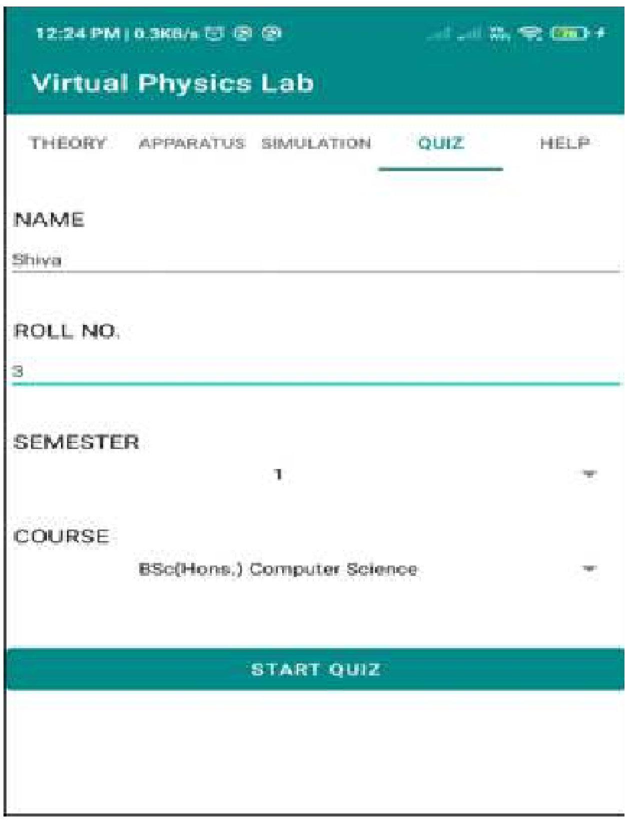

Fig. 12 : Application screen for feeding data for accessing the quiz questionnaire under the Quiz tab

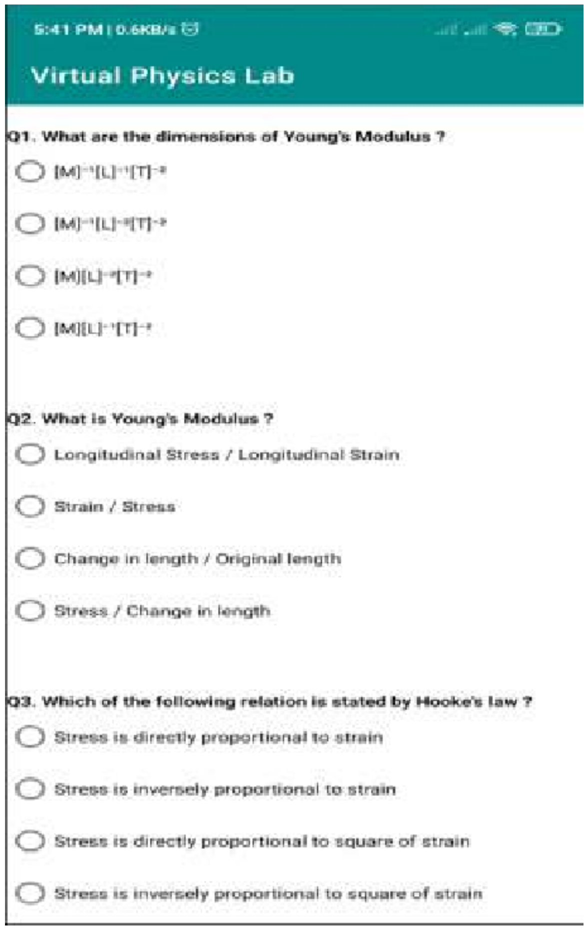

Fig. 13 : Quiz questionnaire under the Quiz tab

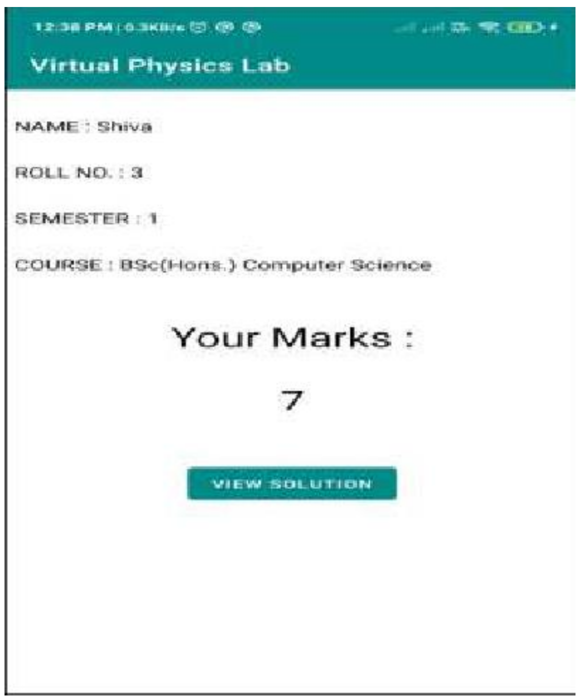

Fig. 14 : Screen showing the result of the quiz under the Quiz tab

The student can respond to MCQs about the chosen experiment by clicking the Start Quiz button, as shown in Fig. 13. The quiz results and accurate responses are displayed as soon as the student clicks the submit button, as seen in Fig. 14.

5. Validation and Evaluation of The Proposed Learning Management System

COVID-19 has forced people to change the traditional ways of the mainstream education system. The pandemic has transformed the shift to online education to reduce the risk of infectious diseases. Preliminary VLs have somehow managed to conduct experiments and practical work in the online education model. Besides being used for online experiments during the pandemic, the lack of infrastructure and sometimes the risks associated with conducting experiments are other motivating factors driving the use of VL. A complete LMS that could provide a dedicated VL along with the assessment of students by teachers is the need of an hour.

In this work, an Android-based LMS using VL is designed for mobile phones and tablets. The proposed LMS enabled the students to perform the experiments in the virtual environment in the same manner as they performed in the physical labs and also facilitated the evaluation of the students by the teacher.

Table 1: Likert Response Labels

Options	10 Points
1	Very Strongly Disagree
2	Disagree Strongly
3	Disagree
4	Mostly Disagree
5	Slightly Disagree
6	Slightly Agree
7	Mostly Agree
8	Agree
9	Strongly Agree
10	Very Strongly Agree

The designed LMS application was demonstrated to a sample of 30 students in a class of an undergraduate course, including teachers and students. A qualitative study requires a sufficient sample size to unearth opposing viewpoints, but not so large that the analysis cannot yield new information (Hennik & Kaiser, 2022). It is possible to reach saturation with a relatively small sample size in qualitative research. According to the findings, nine to seventeen interviews or four to eight focus group discussions reached information saturation (Hennik & Kaiser, 2022). Taking this into account, a class of 30 students was considered, and the sample size was determined by the average number of students enrolled in a class. After recording their responses on the feedback form provided in Appendix 1, a content analysis was conducted on their feedback. A 1–10 Opinion Scale Survey was administered to measure student satisfaction, with rating options ranging from 1 to 10, from which students could choose a score to rate their experience with the developed LMS. As shown in Table 1, Likert response labels (Taherdoost, 2019) reveal that a score of 10 indicates the most positive experience, and a score of 1 indicates the most negative experience. To provide respondents with quantifiable response options and facilitate content analysis, a 1–10 opinion scale was created. Some respondents provided additional information regarding their experiences with the proposed LMS.

The overall assessment of the developed LMS is shown in Fig.15(a)-(e). Nearly 97% of students found the proposed system was easy to launch and use, as shown in Fig.15(a). The system significantly reduced the setup time and actual time to run tests. It provided a simple and flexible way to conduct experiments, allowed students to record their results electronically, and was supported by almost all students. Nearly 90% of students endorsed that the documentation in the system's Help tab helped them to experiment effectively without a teacher as shown in Fig.15(b). The results obtained after testing the proposed system were correct for all students, as shown in Fig. 15(c). The proposed LMS also provided the teachers with the facility to effectively design and evaluate assignments using electronic media. As shown in Fig. 15 (d), nearly 97% of teachers could accurately assess and document achievements using the developed LMS. Experimental results and conclusions could be easily shared for class discussion. Therefore, the use of the system allows for a high degree of interaction between teachers and students. As shown in Fig. 15(e), 93% of students approved and recommended the use of LMS during regular teaching and learning.

One of the most important goals of e-learning is to develop well-defined content with clear learning outcomes. The proposed LMS can help achieve this goal of learning through virtual lab experiments. As a

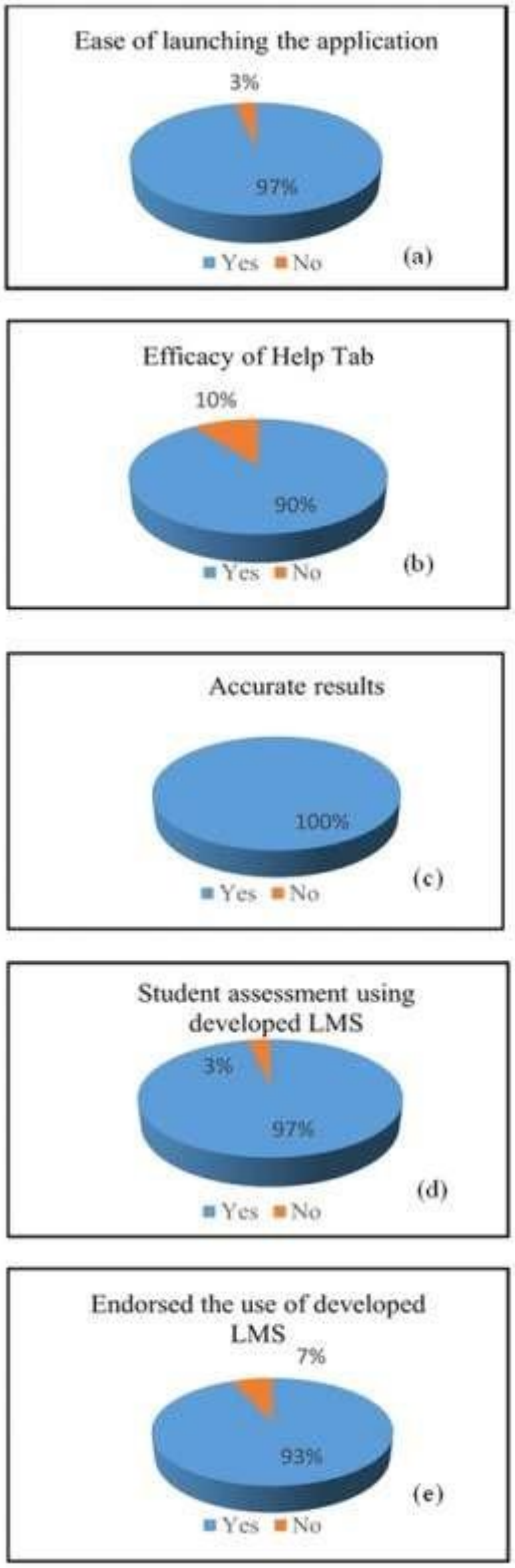

Fig. 15. Overall assessment of proposed LMS (a) the ease of launching (b) Efficacy of Help Tab (c) Accurate results (d) Student Assessment using developed LMS (e) Endorsing the use of developed VL

result, incorporating VLs into the regular classroom teaching-learning process can supplement regular teaching by allowing more effective implementation of ideas. Teachers can also use the latest technologies of the digital age to support students at every stage of their learning.

To determine the effectiveness of the presented learning platform in mapping PLOs to CLOs, critical aspects of use such as independent comprehension, a clearly defined procedure for conducting experiments, usability, and an assessment mechanism for evaluating conceptual knowledge were reviewed. A sample of 30 students was divided into two groups. Group I students were required to experiment in the Physical Lab (PL) in groups of three within a three-hour time limit, and group II students were taught the concepts individually through the Virtual Lab (VL). The teachers were asked to design a questionnaire to quantify the evaluation of the concept disseminated via VL and PL, respectively.

In addition to facilitating remote experimentation, the proposed LMS offered students extensive preparatory materials and a step-by-step experimental procedure for conducting the experiments. As a result, it was found that nearly 93.3% of students who experimented with LMS scored above 80% on the questionnaire. This clearly shows that they understood the theory and ideas behind the experiment better than the 46.7% of students who experimented only in the labs. Because the platform could be used at the student's own pace, it was possible to repeat the same experiments with different parameters while keeping the same VL course objectives and outlines. This provided the students with additional opportunities to investigate, analyse, and interpret data. Students were able to troubleshoot their experiments and understand the values of precise measurements. Students who did experiments in PL, on the other hand, could only take a few sets of readings with different parameters.

Through the proposed LMS, teachers could easily prepare and manage assessment questions. They distributed the questionnaire to batches of Group I students, scheduled the assessment time, and monitored their responses via the LMS. This allowed the teacher to quickly evaluate the student's understanding of the physics concept at hand and inform them of their errors immediately after a check. The evaluation of Group II students, on the other hand, was a time-consuming process involving the manual distribution of questionnaires and the manual checking of those questionnaires by teachers. As a result, there was little interaction between teachers and students. Thus, the PLOs and CLOs were successfully mapped using the proposed LMS.

6. Comparative Analysis

A virtual lab is an online learning environment designed to help students acquire laboratory-related skills. VLs are among the most beneficial forms of e-learning due to the time and location constraints students face when attending conventional laboratories. The integration of VLs with a LMS is an efficient method for teaching students of all skill levels. This is an example of an ICT-based learning process that could be substituted for the conventional practice-based learning method.

The literature describes some work in Virtual Physics laboratories. Physics Lab by Turtle Sim LLC (TurtleSim, 2020) enables teachers to demonstrate experiments and assist in the classroom. Students have limited input value options and no way to modify the default settings. Teachers cannot administer quizzes, which are used to evaluate students' comprehension of course material. No system in place allows teachers to monitor the students' grades. Furthermore, experiments in Turtle Sim LLC's Physics Lab (TurtleSim, 2020) require an internet connection.

Abbasi's (Abbasi, 2021) Physics virtual lab allows students to select input parameters or move instruments by touching the screen and then observing the results. Formulas are provided for better understanding. Even though the virtual lab is easy to use and has a lot of physics lessons, there is currently no way for teachers to keep track of how their students are doing. Evaluation is an important part of learning because it shows whether or not the learning goals of the course have been met. Evaluation of learning objectives is the primary purpose of all forms of teaching.

Virtual Labs by MoE (https://www.vlab.co.in/) is a web application that works best on a laptop. For VL experiments, students require constant online connectivity. Although pre-tests and quizzes are available in their labs, teachers cannot create custom quizzes for their students. In addition, they have no way of determining how well the students perform the quiz.

VLs should provide a complete lab experience for online courses. They should provide platforms with screens that simulate physical labs. The online experience should provide students with the same resources as the physical lab. It should let students redo experiments and, unlike traditional labs, give them more than one chance to figure out where they went wrong. Assessment plays an important role in the learning and motivation processes, and in this lab implementation scenario, teachers would need a variety of assessment options to evaluate student performance.

The proposed LMS that is integrated with VL permits students to utilise a variety of feasible input variations. Students don't have to worry about network connectivity because it can be used without the internet. It is an Android application that is compatible with mobile phones with less stringent system requirements. Due to the recording of all experiment results, teacher-student communication becomes more efficient.

7. Conclusion

COVID-19 has completely disrupted and forced academic institutions to switch to online knowledge dissemination. ICTs are now becoming an integral part of the education system for delivering and managing education, as they facilitate the acquisition and assimilation of knowledge. Concept formation is the initial step in acquiring knowledge in any field, and experience makes it easier to absorb, understand, and accept concepts. Due to social distancing obligations, the ongoing pandemic has also halted the conduct of laboratory-based scientific experiments. Preliminary virtual science labs were utilised by teachers and students worldwide to conduct experiments in response to this circumstance.

During the current pandemic, it was envisioned that students would be able to conduct experiments in a virtual lab that is comparable to physical labs. The proposed system was developed using the Integrated Development Environment of Android Studio. Teachers and students can install the system on their mobile phones and tablets. The system facilitates practical teaching-learning and aids in comprehending the concept and its real-world applications.

The proposed system improves students' knowledge of scientific subjects, equips them with the tools necessary to develop scientific reasoning and practical skills, assists them in comprehending what science is, and uses online media to stimulate their interest in science. The LMS presented in this work enables students to complete hands-on work at their convenience without violating safety standards. Teachers can use the system to create quizzes for evaluating students without having to travel to physical labs. This saves a great deal of time and effort.

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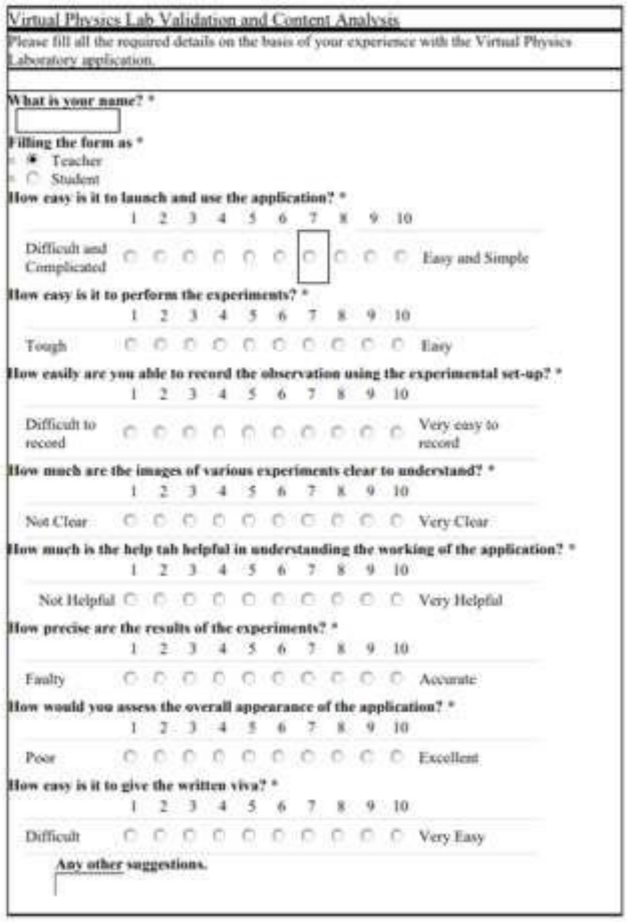
Appendix - 1


Virtual Physics Lab Validation and Content Analysis

Please fill all the required details on the basis of your experience with the Virtual Physics Laboratory application.

What is your name? *

Filling the form as *
- Teacher
- Student

How easy is it to launch and use the application? *
1 2 3 4 5 6 7 8 9 10
Difficult and Complicated — Easy and Simple

How easy is it to perform the experiments? *
1 2 3 4 5 6 7 8 9 10
Tough — Easy

How easily are you able to record the observation using the experimental set-up? *
1 2 3 4 5 6 7 8 9 10
Difficult to record — Very easy to record

How much are the images of various experiments clear to understand? *
1 2 3 4 5 6 7 8 9 10
Not Clear — Very Clear

How much is the help tab helpful in understanding the working of the application? *
1 2 3 4 5 6 7 8 9 10
Not Helpful — Very Helpful

How precise are the results of the experiments? *
1 2 3 4 5 6 7 8 9 10
Faulty — Accurate

How would you assess the overall appearance of the application? *
1 2 3 4 5 6 7 8 9 10
Poor — Excellent

How easy is it to give the written viva? *
1 2 3 4 5 6 7 8 9 10
Difficult — Very Easy

Any other suggestions.

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