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Design and Development of automatic lab data analyzer and evaluator

Tushar[1], Dr. Niranjana K M[2], Saravanan C[3]

PG Student, Master of Computer Applications, Rashtreeya Vidyalaya College of Engineering, Bengaluru- 560059[1]

Assistant Professor, Department of Physics,Rashtreeya Vidyalaya College of Engineering, Bengaluru- 560059[2]

Assistant Professor, Department of Master of Computer Applications, Rashtreeya Vidyalaya College of Engineering, Bengaluru- 560059[3]

Abstract: The evaluation process carried by faculties in Physics labs face numerous challenges. The traditional approach relies on manual evaluation of the experimental results and respective calculations carried by the student. This manual method, not only consumes considerable time and effort if done thoroughly but also introduces the potential for human errors, impacting the correctness of evaluations. Faculty members had the arduous task of manually reviewing each student's records, making the assessment process time-consuming and potentially prone to subjectivity. Because of this reason, most of the times faculties just check whether the final calculated result is within the expected range or not and simply glance over the intermediate steps. Also faculties wrongly attribute the deviations in the calculated value from standard values to random error instead to lack of experimental skill of the student. It is because they don't standardize the samples they use in the experiment. In some of the cases students simply doesn't calculate at all. They just copy the calculations from their friends or simply write a number in the expected answer range. Many times if faculties calculate for the data presented by the students, the answers don't match! Present article suggests an idea for creation of an advanced web portal to address these significant issues and modernize the evaluation method. Here the lab experiments are evaluated by utilizing the Flask, SQLite database for back-end and HTML, CSS, JavaScript for front-end. Students will input their observations in a more streamlined and error-free manner and faculties will be able to see the right calculations for the entered data so that they can use it to verify the results presented by the students. The correctness of the evaluation process will be guaranteed.

Keywords: Digital system ,evaluation,database, Flask

I. INTRODUCTION

A fascinating research into the basic principles of numerous physical phenomena can be located in the discipline of physics. Physics is the cornerstone of real-world breakthroughs and applications in engineering education. In many academic institutions, first-year engineering students are obliged to complete the Physics cycle, which involves performing a number of lab experiments. However, that number of experiment is evaluated by faculty that is very difficult and time consuming for the faculty. The traditional evaluation procedure for these research. This has made it necessary to find an original and technologically advanced approach to update the evaluation system.

The project's main objective is to automate the lab data analysis and evaluation system, giving professors a quick and precise way to evaluate the work of their students. Members of the faculty will have access to a real-time evaluation platform through this cutting-edge portal, enabling quick feedback and visualization of observation data. Using this as a foundation representation, students will be better able to analyze the results of their experiments, spot trends, and develop their analytical abilities, leading to a deeper comprehension of physics ideas.

The suggested web portal aims to increase the efficacy and transparency of the review process by removing the manual evaluation and adding data analytics tools. The project also intends to cut down on physical labor and paper usage in line with sustainable and eco-friendly standards. In the end, the creation of this robotic lab data analyzer and evaluator having the capacity to revolutionize the current assessment process by offering instructors and students a more sophisticated and efficient method of conducting physics lab experiments.

The proposed effort, named "Design and Development of Automatic Lab Data Analyzer and Evaluator," aims to create a web site that will revolutionize the way physics.There are lab experiments conducted and evaluated in order to address these urgent challenges. The project makes use of SQLite as the database management system, Flask as the back-end framework, and HTML, CSS, and JavaScript as the front-end interface language. The portal intends to streamline the recording of observation data and experiment findings by integrating various technologies, allowing students to input their data with simplicity and accuracy.

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II. BACKGROUND

The rapid advancements in technology and the increasing adoption of digital tools in education have paved the way for more efficient and effective learning environments. As such, there is a growing demand for automating educational processes to enhance productivity and promote student-centric learning.

In recent years, web-based applications and platforms have gained popularity in educational institutions,providing various benefits over conventional methods. The proposed web portal for automatic lab data analysis and evaluation capitalizes on these advantages to offer the best answer possible for the Physics lab assessment.

Making advantage of Flask as the back-end framework offers a lightweight and flexible approach, making it suitable for the development of a web to offer the best answer possible for the front-end interface. SQLite, a self-contained and server-less relationship-based database management system, which offers an efficient means of storing and retrieving data.The integration of HTML, CSS, and JavaScript in the front-end interface enables a user-friendly and interactive experience for both students and faculty members.

By automating the lab data recording process, students can input their observation data and experiment results with precision, reducing the likelihood of errors and facilitating a more accurate evaluation. Faculty members, in turn, they'll have use of a real-time evaluation platform, enabling timely and constructive feedback to students.

III. LITERATURE REVIEW

Helen Onyeaka et al. A key element of instructional methodology is the visual presentation of laboratory procedures. Pre-lab video demonstrations in a first-year chemical engineering course assist students have a better laboratory experience. The study's main goals were to make movies that would be used as teaching aids in undergraduate lab classes and assess how well the students learned as a result.[1]

Satyen Gautam ,At the start of the semester, Students got access to online courses at the beginning of the semester thanks to a platform with an integrated virtual learning environment. By creating a dynamic educational setting that could accessed at home or at school, students were given the possibility of engage in independent study. Students had to watch the relevant screen casts and finish a self-assessment quiz before the lab session.[2]

Lerro; Increasingly common for students to use a learning management system (LMS) and a remote laboratory independently. However, we acknowledge that giving students access to distant laboratories and allowing them to do real scientific experiments there from an LMS is highly beneficial for them. The integration of both educational resources is one of the objectives of a project developed by a collaboration between a governmental institution (UNR) and a technical business named "educativa."[3]

Simon Zacharias Lahme et al. Physics lab courses have lately undergone significant changes in order to match the emergence of new digital technologies and the Covid-19 pandemic, which made online learning possible. Since these changes frequently occur inside certain institutions, it is beneficial to get a general picture of these developments by describing the state of digital technology at the moment.[4]

Hamed, Ghadeer ,Effects of using virtual experiments on students' academic performance, practical proficiency, and opinions of using the experiments in a general physics lab. Background There is continuous debate in the literature about how using virtual experiments and labs affects students' understanding of physics and if these experiments can replace or enhance students' performance in the actual lab. [5]

Salome Wörner, We implore teachers to avoid undervaluing any kind of experimentation (RE or VE), as doing so may be advantageous. Since each experiment has a specific objective and there may be linkages between different experiments and the student's prior knowledge, it is necessary to carefully evaluate how to integrate various experiments. Teachers are crucial in creating an environment that supports RE and VE learning because they are in charge of selecting, creating, and organizing the educational activities. Science Educators are important because are essential facilitators of effective inquiry learning, according to De Jong et al. (2013).[6]

Mark Turner,"Pedagogical Approaches in Online Experimentation",Mark Turner's literature survey explores various pedagogical approaches employed in online experimentation environments. He reviews platforms that incorporate active learning strategies, personalized feedback mechanisms, and real-world context to enhance students' practical

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skills and theoretical understanding[7].

Rachel Wilson,"Innovations in Laboratory Management Software",Rachel Wilson's survey focuses on recent innovations in laboratory management software, particularly in the context of web-based systems. She discusses how these platforms streamline experiment data collection, offer seamless graphing capabilities, and enable instructors to monitor student progress effectively[8].

Andrew Clark,"Advancing Science Labs with Data Visualization Tools",Andrew Clark's literature survey examines the integration of data visualization tools in advancing science labs. He explores how web-based platforms leverage advanced graphing libraries and visualization techniques to empower students with deeper insights into experimental results and scientific phenomena [9].

IV. METHODOLOGY

A.Database Design

Our project involves designing a comprehensive database to efficiently manage and store laboratory observations conducted by students. The database design encompasses three crucial aspects: conceptual design, logical design, and physical design.

- Conceptual Design

At the conceptual design stage, we focus on understanding the essential entities, relationships, and attributes that form the backbone of our database. We identify key entities such as students, experiments, observations, and samples. Each entity is connected with its specific attributes, like student IDs, experiment IDs, observation dates, and sample names. The Relationships are created between entities. to ensure data integrity and consistency. The conceptual design serves as the foundation for the subsequent stages, providing an abstract representation of the data flow within the system.

- Logical Design

Moving forward with the conceptual design, we transform the abstract representation into a logical design. In this stage, we map the entities, relationships, and attributes into tables, columns, and constraints. We define the primary and foreign keys to establish connections between tables and ensure referential integrity. The logical design provides a blueprint for the database structure and lays the groundwork for creating the actual database schema.

- Physical Design

In final stage, we delve into the physical design of database. Here, we focus on optimizing performance, storage, and access efficiency. We decide on the data types, indexing strategies, and table normalization to minimize redundancy and maximize data retrieval speed. The physical design ensures that the database can handle large volumes of observations while maintaining data integrity and security.

B. Architecture Design

The design stage for software and computer architecture is referred to as high-level design. All common lists of modules, a brief summary of each module's functionality, linkages between the modules' interfaces, and dependencies should be included in the model used to select the architecture.,among other things, a technical specification, a database table, and an architectural diagram.

Once the system's needs are identified, the essentials for the hardware, software, data resources, and information products that would satisfy the functional requirement of the proposed system can be defined. This design will act as the overall system's outline to manage and identify the connections between various components, as seen in fig. 2.

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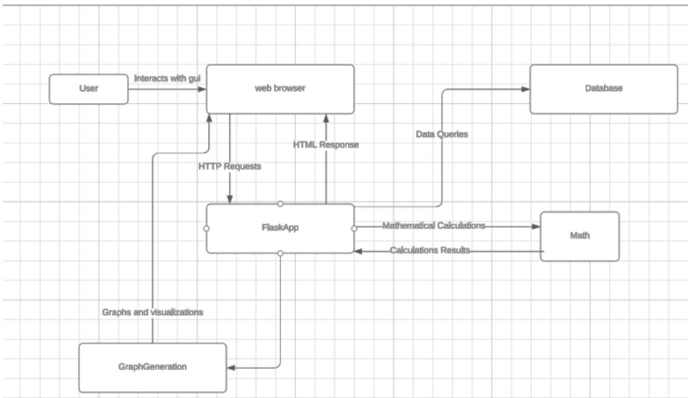

Fig1 Proposed system

C. Interface Design
User Interface (UI) Design places a strong emphasis on anticipating what users will do and making sure the connection has features that are simple to use, understand, and access. This user interface combines ideas from information architecture, interaction design, and visual design.

D. Module Design
Low-level design known as the module design stage. The suggested system has been split up into more manageable portions or segments, and each one is described, indicating that the programmer can begin writing code. The flowchart of the entire system, which is a low-level design program specification with a complete functional reasoning in the module pseudo-code, was explained in Fig 3.

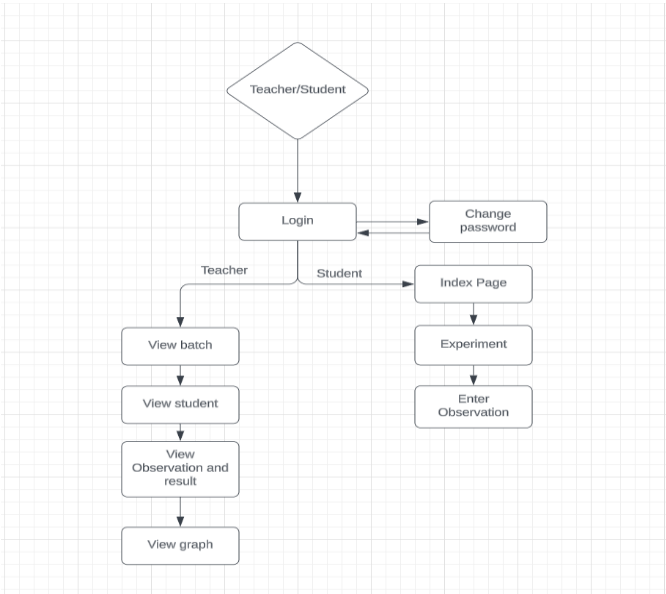

Fig 2 flowchart of proposed system

V. EVALUATION METHOD

The system testing procedure sought to identify any flaw in our project. This program was put through a series of test inputs, and different observations were made. It will be determined whether or not the program behaves as expected based on these observations. Testing levels: -

A. Unit Testing
Unit Test Plans (UTPs) are created during the stage of module design of the V-Model. These UTPs are used to fix issues that are present at the unit or code level. The smallest thing that can live on its own is called a Unit, such a

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software module. Despite being separate from the other codes, the smallest object can nevertheless operate correctly thanks to unit testing.

B. Integration Testing

In the architectural design phase, integration test plans are implemented. These tests demonstrate that the unit can cohabit and communicate as it was formed and independently confirmed. The customer's group is informed of the test results.

C. System Testing

Plans for system tests (STP) are created throughout the system layout phase. STP is made up of the client's business division and separate Integrated and unit testing Plans. System testing demonstrates this. an application designer's expectations were met. The functioning, interdependence, and communication of the entire application are checked. System testing demonstrates the fulfillment of both useful and ineffective requirements. System testing includes several subsets such as Testing for load and performance, stress, regression, etc..

D. User Acceptance Testing

In the analysis phase, strategies for User Acceptance Testing (UAT) are established. Business users make up test strategies. UAT was completed using reliable data in a setting where users closely resembled the environment during production. UAT demonstrates that the provided system satisfies the the needs of the user, and is prepared for usage in real-time.

VI .EXPERIMENT RESULTS

We will talk about the outcomes of the suggested system in this part. These outcomes will assist us in proving that the suggested solution successfully and efficiently grants users access. The relevant results are explained in Table.1 starting with the Test Plan's explanation within the system requirements, functional specifications, and design specifications. Even yet, it is advantageous for users to weigh the benefits of utilizing an electronic system against the drawbacks of a manual one.

Figures 3–5 depict the graphical interface of the Design and Development of automatic lab data analyzer and evaluator; they provide the basic page where students and teachers can click to access the web portal. Figure 4 depicts the login process; students can log in using their username and password. As shown in Figures 4 and 5, once they've logged in, students can access the index page, which contains the experiment, and then execute the experiment by inputting the observation and submitting it. Students may do many sets of observations. As data is supplied, teachers must also log in. Fig. 6: Once logged in, instructors can check student details, as well as the quantity of experiments done by students and they can view the observation entered by them and result and graph will be also generated with help of observation data.

Test Case	Feature Tested	Sample input	Expected output	Actual output
Login	Check username & password	If the user's information is incorrect,an error notice will be displayed.	Grant access to the applicable main system	User successfully logs into the system upon submission of correct login credentials.
Observation data	Enter valid data	Set-1 Observation1-12 Observation2-23	Data saved	Entered data will be saved.
Link Availabilit	Observation Link Availability	Student ID: "1RV21CS110" Experiment ID: 1	Link shown	Link will be shown to teacher
Batch	Visbility to teacher	batchID:”AI1”	Batch shown	Batch will be visible to teacher

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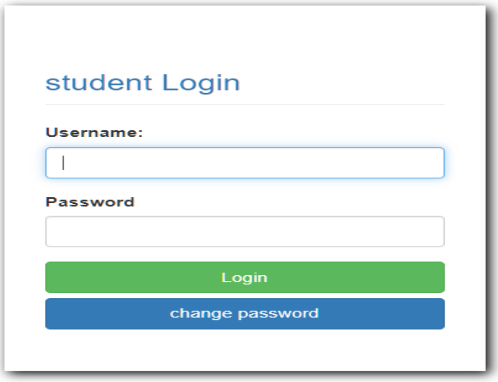

Fig 3 Login page

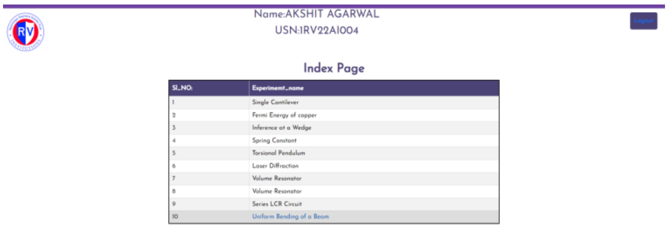

Fig 4 Index page

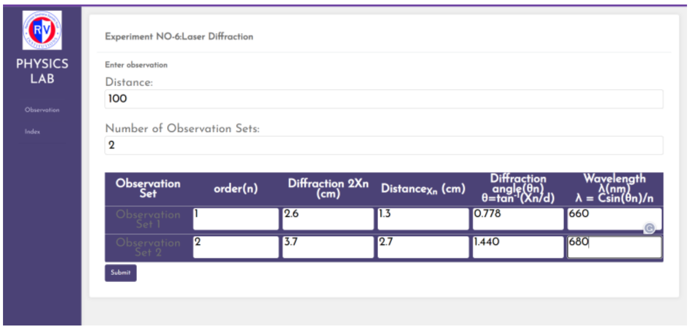

Fig 5 Observation page

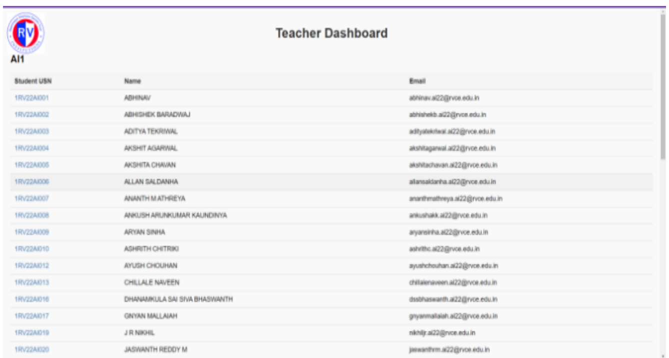

Fig 6 Teacher portal

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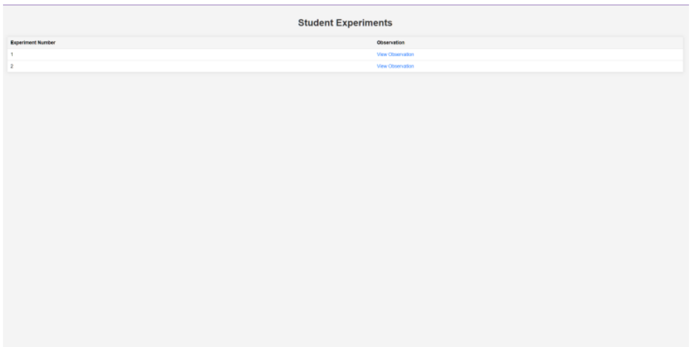

Fig 7 Student Experiment

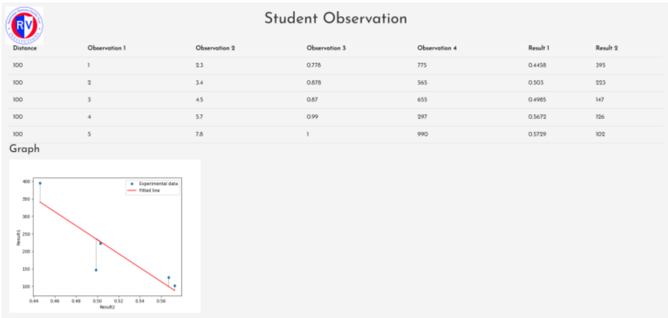

Fig 8 Student Observation/result

VII. CONCLUSION

In conclusion, The endeavor was to automate the manual process of lab manual work for students and simplify the evaluation process for teachers. By implementing a web-based portal, the project accomplished its goals satisfactorily. and provided an efficient and user-friendly platform for both students and teachers.

Through the portal, students may log in and register to access their experiments and enter their observations. The system ensures the accuracy and integrity of the data by validating the inputs and storing them in a secure database. Students can conveniently submit their observations and view their experiment details. Additionally, the system generates graphs and calculated values according to the observations, providing a visual representation of the data.

For teachers, the portal offers features like student management and experiment management. Educators can register, log in, and view a list of students assigned to their batches. They can access the experiments conducted by students, review their observations, and provide feedback. The system also allows teachers to view graphs and analyze the data collectively or on an individual basis.

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