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LabVerse AI: An AI-Powered 360° Virtual Laboratory

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ABSTRACT – Practical laboratory work is essential for understanding scientific concepts, yet many institutions lack the equipment, space, funds and safety infrastructure to provide it. This paper presents LabVerse AI, an AI-powered virtual laboratory in which students explore a 360-degree immersive lab, select virtual tools and perform Physics and Chemistry experiments step by step. An integrated AI assistant guides the student through each procedure, explains the underlying concepts and helps interpret the observed results. The paper describes the objectives, the limitations of existing systems, the proposed system, its workflow and methodology, and its advantages. LabVerse AI aims to make practical learning accessible, engaging, safe and cost-effective without requiring a fully equipped physical laboratory.

Keywords – virtual laboratory, artificial intelligence, 360-degree environment, e-learning, Physics, Chemistry, AI assistant.

I. INTRODUCTION

Science education depends on hands-on experimentation, which helps students connect theory with observation. However, physical laboratories are expensive to build and maintain, need trained staff, and expose beginners to risks such as chemical spills, burns and electric shock. In many schools and colleges, students therefore perform few experiments or only watch demonstrations [1], [2].

Virtual laboratories have emerged as a complement to physical ones, and studies report that they can support conceptual learning comparably to hands-on work in many settings [3], [4]. Most existing tools, however, are two-dimensional simulations with limited exploration and no personalised guidance. LabVerse AI combines an immersive 360-degree lab with an AI assistant that acts as a virtual instructor.

II. OBJECTIVE

The main objective of LabVerse AI is to provide an accessible, safe and interactive environment in which students can learn scientific concepts through realistic virtual experiments. The specific objectives are:

1) To build a 360-degree virtual laboratory in which students can look around and examine laboratory equipment.

2) To let students select virtual tools and perform Physics and Chemistry experiments step by step.

3) To integrate an AI assistant that guides procedures, explains concepts and answers experiment-related questions.

4) To reduce the cost, space and safety risks associated with physical laboratories.

5) To design the platform so that further subjects and experiments can be added easily.

III. EXISTING SYSTEM

A. Traditional Physical Laboratories

Conventional laboratories give direct experience with real apparatus. Their drawbacks are high set-up and consumable costs, limited equipment per student, fixed schedules, the need for continuous supervision and exposure to hazardous materials. Students cannot repeat an experiment freely, and a mistake may waste materials or cause an accident.

B. Existing Virtual Labs and Simulations

Current virtual labs and interactive simulations, such as PhET [5], reduce cost and risk. Many, however, present a flat, 2-D view with predefined animations. They offer little sense of presence, restrict the student to a fixed sequence of actions and provide only static help text instead of answering a student's own questions.

C. Limitations

The main limitations of existing systems are: (i) lack of immersion and spatial exploration; (ii) no intelligent, on-demand guidance; (iii) limited freedom in choosing tools; (iv) poor explanation of results; and (v) dependence on physical resources or institutional access. Table I compares the approaches.

TABLE I
COMPARISON OF LABORATORY APPROACHES

Parameter	Physical lab	2-D simulation	LabVerse AI
Cost	High	Low	Low
Safety risk	Present	None	None
Immersion	Real	Low	360° view
Guidance	Instructor only	Static text	AI assistant
Repeatability	Limited	High	High
Access	On campus	Online	Online / anywhere

IV. PROPOSED SYSTEM

LabVerse AI is a virtual laboratory platform with three cooperating parts: an immersive 360-degree lab environment, an interactive experiment module and an AI assistant. After choosing a subject, the student enters the lab, inspects the equipment, selects the tools required and carries out the experiment while the assistant explains each step and answers questions.

A. Key Features

The key features are the 360° virtual lab, interactive step-by-step experiments, the AI assistant, support for multiple subjects and a safe, accessible practice environment. Table II maps each feature to its function.

TABLE II
KEY FEATURES OF LABVERSE AI

Feature	Description
360° Virtual Lab	Immersive exploration of laboratory equipment and layout.
Interactive Experiments	Select virtual tools and perform experiments step by step.
AI Assistant	Guidance, concept explanations and answers to experiment-related questions.
Multiple Subjects	Physics, Chemistry and other scientific subjects.
Virtual Learning	Safe, repeatable practice in an accessible digital environment.

B. System Modules

The system consists of: (1) a user module for registration, login and subject selection; (2) a 360° lab module that renders the environment and equipment; (3) an experiment engine that stores procedures, checks tool choices and computes outcomes; (4) an AI assistant module that interprets student queries in the context of the current experiment; and (5) a feedback module that summarises results and learning progress.

V. METHODOLOGY

The development of LabVerse AI follows the workflow shown in Fig. 1.

A. Requirement Analysis

Physics and Chemistry experiments from the school and undergraduate syllabus are analysed to list the apparatus, procedural steps, safety precautions and expected observations for each.

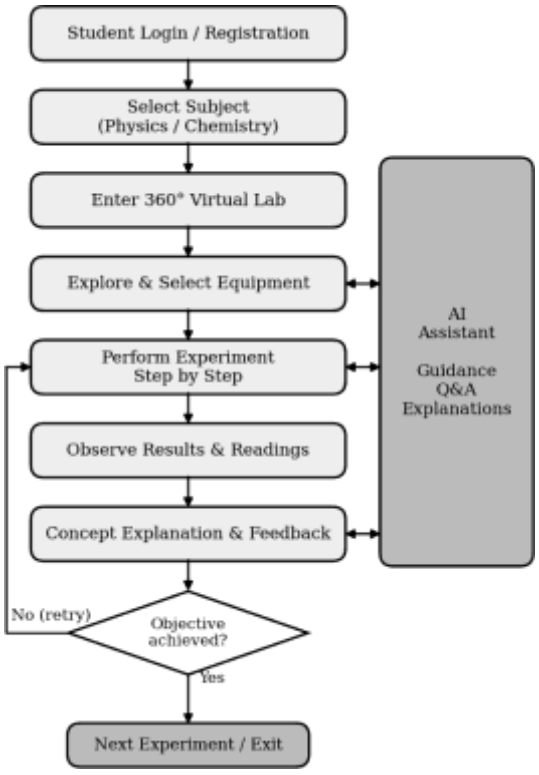


Fig. 1. Workflow of the LabVerse AI virtual laboratory.

B. Environment and Equipment Modelling

The laboratory is modelled as a 360-degree scene in which each instrument (for example beaker, burette, pendulum or multimeter) is an interactive

object with its own properties and permitted actions. Students rotate the view, zoom and select equipment from the bench.

C. Experiment Engine

Each experiment is defined as an ordered set of steps with required tools and rules governing the result. When the student performs an action, the engine validates it, updates the virtual state (such as a colour change or a meter reading) and records the outcome. Incorrect tool choices produce corrective hints instead of unsafe outcomes.

D. AI Assistant Integration

The AI assistant receives the student's question together with the experiment context, current step and recent actions. It returns step guidance, explanations of the underlying concept and interpretations of observed results in simple language. Responses are limited to the active experiment and subject to keep answers relevant and accurate.

E. Testing and Evaluation

The prototype is to be evaluated through functional testing of each experiment and a classroom study comparing learner understanding, engagement and task completion before and after using the platform. Sample experiments are listed in Table III.

TABLE III
SAMPLE EXPERIMENTS SUPPORTED

Subject	Experiment	Concept learned
Physics	Simple pendulum	Time period and length
Physics	Ohm's law	Voltage–current relation
Chemistry	Acid–base titration	End point and neutralisation
Chemistry	Salt analysis	Identification of ions

VI. ADVANTAGES

1) Cost-effective: no expensive apparatus, chemicals or laboratory space is required.

2) Safe: students can try hazardous experiments without risk of injury or accident.

3) Accessible: learning is possible anytime and anywhere with an internet-enabled device.

4) Engaging: the 360° environment and hands-on interaction improve motivation and a sense of presence.

5) Personalised: the AI assistant answers questions and explains results at the student's own pace.

6) Repeatable and scalable: experiments can be repeated without wasting resources, and new subjects can be added.

VII. CONCLUSION

This paper presented LabVerse AI, an AI-powered virtual laboratory that combines a 360-degree environment, interactive step-by-step experiments and an intelligent assistant. By making practical learning safe, accessible, engaging and affordable, it can extend laboratory experience to students who lack physical facilities and can complement existing laboratories. Future work includes adding more subjects such as Biology, supporting virtual-reality headsets, multi-student collaboration and learning analytics, and validating learning outcomes in classroom studies.

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