Identification and Classification of Virtual Lab Apps in Science: A Content Analysis Approach

Dr. Kumari Vineeta*, Dr. Ajay Surana**

**Research Scholar, Department of Education, Banasthali Vidyapith, Rajasthan & Lecturer, District Institute of Education and Training, Banka, Bihar. Email- vineeta.priyadarshi@gmail.com

** Professor cum H.O.D., Department of Education, Banasthali Vidyapith, Rajasthan-304022. Email-toajaysurana@gmail.com

HOW TO CITE:
Kumari Vineeta, Ajay Surana (2026). Identification and Classification of Virtual Lab Apps in Science: A Content Analysis Approach. International Journal of Special Education, 41(10s), 1221-1238

COPYRIGHT STATEMENT:
Copyright: © 2026 Authors.
Open access publication underthe terms and conditions of the Creative CommonsAttribution (CC BY) license (http://creativecommons.org/licenses/by/4.0/).

ABSTRACT:
Virtual laboratory applications are increasingly emerging as effective alternatives to traditional science labs, especially where physical infrastructure is limited. This study focuses on the identification and classification of virtual lab apps relevant to secondary-level science using a content analysis approach, evaluating selected applications based on criteria such as content coverage, technical feasibility, language, rating, developer, origin country and cost. The findings indicate that while many Apps offer accessible and cost-effective learning opportunities, there are notable differences in quality, usability and pedagogical effectiveness. The study proposes a structured classification framework to support educators, researchers and secondary level students in selecting appropriate tools and highlights the potential of virtual labs to enhance student engagement and conceptual understanding, while also emphasizing the need for further standardization and improvement.

Keywords: Virtual Labs, Virtual Lab Apps, Content analysis, Classification framework, Technical feasibility, App stores.

1. Introduction

The advancement of digital technologies has significantly transformed science education, particularly through the emergence of virtual laboratory applications. Virtual labs provide learners with opportunities to perform experiments in a simulated or remote environment, overcoming constraints related to cost, safety and accessibility. Virtual laboratories (VLs) have become an increasingly important tool in science education for secondary-level students, offering interactive and flexible environments where learners can conduct experiments and explore scientific concepts. Unlike traditional laboratories, VLs allow students to manipulate variables, repeat experiments multiple times and visualize outcomes in real time without constraints related to time, cost or safety. This is particularly beneficial in subjects such as physics and chemistry, where experiments may involve complex procedures or hazardous materials. Studies have shown that VLs promote "learning by doing," enabling students to actively engage in the learning process and develop critical thinking and problem-solving skills (Rajendran & Divya, 2010; Fridman, 2014). More recent research further supports these findings, indicating that virtual labs significantly enhance conceptual understanding and learning outcomes when

effectively designed and implemented (Raman et al., 2022; Li & Liang, 2024). Additionally, virtual labs enhance conceptual understanding by linking theoretical knowledge with simulated practical experiences, making abstract concepts more accessible to learners (Hakim et al., 2016).

For secondary-level students, VLs also support motivation and engagement by providing immersive and visually rich learning experiences. The incorporation of animations, simulations and interactive features has been found to significantly improve students' attitudes toward science and their academic achievement (Akpınar, 2014; Karacop & Doymus, 2013). Recent studies highlight that the integration of learning analytics and advanced technologies in virtual labs further strengthens student engagement , motivation, deep learning, personalized learning experiences and learning outcomes (Elmoazen et al., 2023; Rosli & Ishak, 2024; Mila Dodevska et.al. 2025, Shah, Syed F. et.al. 2024). Furthermore, virtual labs are particularly valuable in addressing common challenges faced in traditional laboratory settings, such as limited resources, large class sizes and safety concerns (Ma & Nickerson, 2006). They also enable access to laboratory experiences in remote or distance learning contexts, ensuring inclusivity and continuity in education (Shivam & Wagoner, 2020). One of the main advantage of this may include helpful for people/students with disabilities (Mila Dodevska et.al. 2025). However, while VLs offer numerous advantages, they are most effective when used alongside traditional hands-on laboratories, as they may not fully develop practical manipulative skills or real-world laboratory experience (Hawkins & Phelps, 2013). Due to the constraints associated with traditional physical laboratories, virtual laboratories have emerged as an effective alternative for conducting science experiments. They offer a valuable opportunity to increase student engagement and promote experiential learning without being limited by physical infrastructure (Alsharif, 2024). Virtual science labs serve as accessible and cost-effective solutions that help create a supportive learning environment, enhance understanding and foster students' interest in knowledge construction (Tatira, 2024; Gulsum, 2023) as well as their motivation and Knowledge (Mahendra and Billy Killis 2026). Furthermore, these advanced digital tools have been found to enhance students' curiosity, confidence and overall learning satisfaction (Makransky & Petersen, 2021).

Despite their growing importance, virtual lab applications vary widely in terms of design, functionality and pedagogical effectiveness. There is a lack of systematic classification frameworks that can help educators select appropriate tools and guide developers in improving design. In this context, this study aims to systematically identify and classify science-related virtual lab Apps and evaluate their characteristics and effectiveness. For this purpose, the following research questions were examined:

Research Questions:

1. Too many virtual Lab Apps are available for the Engineering, Polytechnic and Medical fields of higher education, but how many virtual lab apps are available for secondary school science students?
2. India is one of the most developed countries concerning software development, but in the area of VSLA, is the Indian developer able to create a better and sufficient number of VSLA, or is there more foreign contribution available in this field?
3. At the School level, many Virtual Science Lab Apps are available. Can virtual lab Apps developed for the secondary level is classified on various criteria, if yes, then what would be the multiple criteria for the classification of Virtual lab apps available for science at the secondary level?

2. Objectives of the Study

Primary Objective

- To identify, analyse and classify science related virtual lab Apps based on different predefined criteria.

Secondary Objectives

- To identify popular science related virtual lab Apps available on Google and Apple App stores.
- To classify science related virtual lab apps based on content, technical features, language, ratings, origin country and cost to assess their effectiveness**.**

Operational Definitions:-

- **VSLA (Virtual Science Lab Apps):-** A software application designed to run on ICT devices such as phone, PCs, tablets or similar devices that is accessible to perform various experiments in an interactive platform based on simulated lab environments that are highly engaging for secondary school level teachers and students to perform their experiments and analysis of data without the need of physical equipment's.
- **VSLA Module: -**An informative package developed by the investigator to summarize the detailed information regarding available virtual lab apps for Secondary-level science.
- **Origin: -** In the present study, origin refers to the country where these Virtual Science Lab Apps are developed. In this research, only two types will be considered, Indian and Foreign Apps.
- **Branches of Science: -** In this research, a branch of Science refers to a scientific discipline commonly divided into three major groups at the secondary level: Physics, Chemistry and Biology.
- **Content covered: -**In this study, the content covered refers to the different topics of the secondary level NCERT Science book in Virtual Science Lab Apps.
- **Technical feasibility**: - Technical feasibility is an assessment of whether a proposed service is successfully implemented using available technology. Here, in this study, technical feasibility refers to the user- friendliness of VSL App, which encourages end users to use these Apps more frequently. Here, technical feasibility will be seen in terms of system software, application software and hardware specification requirements. The simulation environment provided by the app is also one of the essential aspects of technical feasibility.
- **Language: -** In this study language refers to the language of communication **offered** by the Apps in terms of content material as text, audio, videos available in the VSLA. Language as Hindi or English or any other language or single or multiple languages will be considered for this study.
- **Interface type: -** In present study Interface type refers to the specific method or platform through which users interact with a virtual lab characterized by its design, functionality, and user experience elements. Here interface type will be seen in terms of different dimensions as Platform type, interaction method, functionality etc.
- **Rating: -** Rating refers to the score assigned to an application based on feedback and user reviews, which indicates overall quality and user satisfaction.

3. Methodology

3.1 Research Design

This study adopts a qualitative content analysis approach to systematically examine and classify virtual lab applications with the help of Content analysis method and Comparative method.

3.2. Data Sources

- Primary data-Direct observation and use of some selected Apps
- Secondary data-

i) Google Play Store / App Store
ii) Official websites of apps

3.3. Sample and Sampling Process

The present study employed a qualitative content analysis approach to identify and analyse virtual laboratory applications relevant to secondary-level science education. A purposive sampling technique was used for the selection of applications. Initially, 30 predefined keywords related to virtual laboratories, simulation Lab and Online Lab Apps were used to search applications across major platforms including the Google Play Store and Apple App Store.

Table 3.1 List of searched keywords

VSLA Virtual Science Lab Apps	Online Lab Apps for Chemistry	Virtual lab Apps for STEM Education	Indian Virtual Lab Apps
Science related Virtual Lab Apps	Online Lab Apps for Biology	School Science Lab Apps	Virtual Reality related Scientific Lab Apps
Science related Online Lab Apps	Online Lab Apps for STEM education	Simulated Lab Apps	Virtual Experiment simulator Apps
Online Science lab Apps for secondary level	Virtual Lab Apps	Simulated Lab Apps for school Science	Indian Virtual Lab Apps for secondary level Science
Virtual Lab Apps for secondary schools	Virtual lab Apps for Science	Simulated Lab Apps for school Physics	Online virtual Lab Apps
Science Lab Apps	Virtual lab Apps for Physics	Simulated Lab Apps for school Chemistry	Virtual Lab Apps for Science students
Online Lab Apps for Science	Virtual lab Apps for Chemistry	Simulated Lab Apps for school Biology	
Online Lab Apps for Physics	Virtual lab Apps for Biology	Simulated Lab Apps for school STEM Education	

During the identification process, duplicate and overlapping applications retrieved through multiple keyword searches were removed to avoid redundancy. The selection process included four stages: identification, screening, eligibility and inclusion. Applications were screened based on predefined inclusion and exclusion criteria to ensure their relevance to secondary-level science learning.

The inclusion criteria comprised applications designed for science learning and virtual experimentation, educational relevance for secondary-level students, availability of interactive or simulation-based activities and potential contribution to conceptual understanding and laboratory skill development in Physics, Chemistry and Biology. Applications with unclear educational purpose, non-functional features, duplication or entertainment-oriented content unrelated to science practical learning were excluded.

After applying the screening and eligibility criteria, the final set of 21 virtual Lab applications were selected for detailed content analysis.

Table 3.2 Steps for selection of Virtual Lab Apps

No.	Stages	Description
1.	Identification	In the initial stage, applications related to the research topic were identified using 30 relevant keywords. The search process was conducted across major digital platforms, including the Google Play Store, Apple App Store and Windows Store, to ensure comprehensive coverage of available applications.
2.	Screening	During the screening stage, duplicate and overlapping applications identified across multiple platforms were removed. Subsequently, the remaining applications were screened based on predetermined inclusion and exclusion criteria relevant to the objectives of the study.
3.	Eligibility	In this stage, the shortlisted applications were further evaluated in detail to determine their suitability for the research. The assessment focused on the

		relevance, functionality, accessibility and alignment of the applications with the research objectives.
4.	Included	After the final evaluation process, 21 applications that best satisfied the selection criteria and research requirements were included for detailed analysis in the study.

Coding Scheme

A coding scheme was developed to systematically analyse the selected virtual laboratory applications. The coding categories were derived from the objectives of the study and relevant literature on virtual learning environments and science education. Each application was reviewed and coded according to the following dimensions:

Table 3.3 Coding Scheme

No.	Coding Category	Indicators/Description
1.	Name of the App	Official name of the App provided in stores
2	Direct Link/ Downloaded link	Availability of an official download link or direct access link to the application through digital platform or developer websites for easy accessibility and verification
3	Content	Class-wise or selected topic wise
4	Technical Feasibility	Including Visualisation (Simulation, Animation, Video, AR, VR) and Hardware (Required Android, Download size, Version, Released on and Updated on)
5	Language	Availability and clarity of language options used in the application for instructional and user interaction purposes especially English/ Multilingual
6	Rating	User ratings and reviews available on digital platforms indicating the perceived quality and usability of the application
7	Developer	Information regarding the organization, institution or company responsible for developing the application
8	Origin Country	Country or region where the application or developer organization is based
9	Cost	Availability of the application as free, paid, subscription-based or containing in-app purchases

The coding scheme was used as a systematic framework for the classification, comparison and analysis of virtual laboratory applications based on their educational, pedagogical and technical characteristics.

To ensure consistency and reliability in the analysis, the coding categories were refined through pilot analysis and repeated verification procedures during the coding process.

3.4. Data Collection Methods

Data were collected from official websites and App descriptions, as well as through direct interaction with the applications. The collected data were coded and grouped into categories to identify patterns and relationships. Based on the

analysis, a classification framework was developed.

3.5 Data Collection Tool

Data were gathered using a structured content analysis tool designed to identify and classify online virtual lab Apps available for Science against specific research parameters. A structured checklist was used:

Table 3.4 Structured checklist for available Virtual Lab Apps

Criteria	Description
Application Name	Name of app
Subject	Physics, Chemistry, Biology, Earth science
URL	Download/App link
Content	Classwise/ Topicwise
Technical Feasibility	Visualisation/Hardware
Language	Available languages
Rating	User rating
Developer	Company
Origin Country	Country
Cost	Free/Paid

4. Results and findings

4.1 Overview of virtual Lab Apps

Table 4.1 List of searched Virtual Lab Apps

Sl. No.	Name of the App	Subject and Direct App link/Download App link	Content	Technical Feasibility		Language	Rating	Developer	Origin Country	Cost
				Visualisation	Hardware					
	1	2	3	4	5	7	8	9	10	11
1	**Online Labs(O Labs)**	Biology, Chemistry, Physics, Environmental science and more https://play.google.com/store/apps/details?id=in.edu.onlinelab.olabs	Secondary level Science related class wise content	Simulation	Required Android 5.0 & up Download size-49.32 Version-1.0.15 Released on-09/05/2023 Updated on-06.05.2025	Multilingual (Supports multiple languages Currently, it is available in five langu	4	Developed by Amrita Vishwa Vidyapeetham and CDAC Mumbai. App	India	Free

						ages Hindi, Kannada, Malayalam, Marathi and Tamil.)		maintained by OLabs team, ETU, CDAC Mumbai		
2	**DIKSHA - for School Education**	Science https://play.google.com/store/apps/details?id=in.gov.diksha.app https://diksha.gov.in/virtuallabs.html	Secondary level Science related class wise content	Simulations,Animations, lab videos	Required Android -9.0 and up · Download size-44.44MB · Version- 5.3.3 · Released on-20.07.2018 · Updated on-13.08.2024	Multilingual	4.2	Ministry of Education , Government of India	India	Free
3	**Embibe Lab Experiments**	covers topics in physics, chemistry, biology and other STEM fields https://play.google.com/store/apps/details?id=com.embibe.experiments.prod&hl=en_IN	Topic wise-More than 500 experimen related to CBSE and NCERT and all state boards for class 10th and 12th.	Interactive simulations or video-based	Required Android 8.0 & up demonstrations · Supported on mobiles, tablets, PC or laptop Download size-53.18 MB Version-2.7 Released on-18/03/2022 Updated on-07.04.2026	Multilingual (English, Hindi and regional languages)	4.3	Individual Learning Limited, India	India	Free
4	**PhET Interactive Simulations**	various subjects – Physics, Chemistry, Mathematics, Earth science and Biology https://play.google.com/store/apps/details?id=edu.colorado.phet.androidApp	Topic-wise (168 interactive simulations aligned with class 9,10,11,12 syllabus)	Simulation PhETDesktop App contains all HTML5 and Java simulations, including	Required Android 10 &up Download size-126 MB Version-2.1.0 Released on-21/10/2020 Updated on-24.07.2024	Multilingual (translated into 95 languages)	4.5	University of Colorado Boulder	USA	Paid

				their translations, for offline use on Windows and macOS.						
5	**Praxilabs**	Different field of science as Physics, Chemistry, Biology https://praxilabs.com/en/about-ushttps://phet.colorado.edu/en/offline-access	Topic wise (Electricity, waves, magnetism, heat and thermodynamics)	3D Immersive Interaction Simulation	Required Android 5.1 and up Download size-97.86 MB Version-1.0.10 Released on-18/05/2023 Updated on-09.02.2026	Multilingual (with Simulations Language Customization (upon request) English and Arabic interface)	3.5	Praxilabs	originates from Egypt ,Middle East and North Africa region	Paid
6	**ZeroScience lab virtual labs**	Maths and Science (Physics, Chemistry) https://play.google.com/store/apps/details?id=com.edzhub.edzhub_zeroscience&hl=en https://zerosciencelab.in/	Class 6-12 CBSE curriculum aligned topics from physics, chemistry, Mathematics	Incorporating multimedia elements to enhance the learning process .Use of Simulations	Required Android 5.0 & up Download size-9.95 MB Version-0.3.4 Released on-17/06/2021 Updated on-08.11.23	English	4.4	Edzone International Pvt. Ltd.,	India	Partially free
7	**Tinkercad**	Physics https://play.google.com/store/a	Electronics and coding	3D design and	Required Varies with device Download size-	Accessible throu	English	3.1	Tinkercad	US

		pps/details?id=com.tinkercad.www.twa	for class 6-12	Simulation	822 KB Version-5 Released on-28.02.2022 Updated on-15.07.2024	gh Various Devices				
8	**Science Experiments School lab**	Science https://play.google.com/store/apps/details?id=com.rollingpanda.science.tricks.experiment.learning.lab.school.college	Topic- wise (school laboratories, encompassing physics, chemistry and biology related to class 10 and 12)	Include simulations· Practical related games with voice instructions	.Required Android 5.0 & up Download size-25.86 MB Version-3.5 Released on-07/02/2018 Updated on-12.01.2024	English	4	Rolling Panda Arts	India	Paid
9	**Physics Lab**	Physics https://play.google.com/store/apps/details?id=com.civitas.quantumphysics&hl=en_IN	Various circuit diagram related topics with 100 of circuit components.	·Use of AR mode .Simulation and 3D views .Student can create own experiments	Required Android 6.0 & up · Download size-70.76 MB MB · Version-2.5.2 · Released on-23.03.2018 · Updated on-24.06.2025	Mobile app (Android, iOS), Supported by Android, iOS, Windows	Available in English. Some versions might also support additional languages such as Spanish,	4.1	Netlogo	U.S.

							French, German, or others			
10	**Girls high School Science Lab**	covering physics, chemistry and biology https://play.google.com/store/apps/details?id=com.hazelfunstudio.girls.high.school.science.lab&hl=enn	experiments Including generation of static electricity, gravity, refraction of lights, volcano eruption, biological concepts related to class 9 & 10	Simulated games	Required Android 7.1 & up Download size-29.85 MB Version-1.3 Released on-26/08/2021 Updated on-05.12.2025	English	4	Hazel fun Studio	India	Partially free (Typically free with potential in-app purchases.)
11	**Science Practical Simulator**	Science https://play.google.com/store/apps/details?id=com.SciPracSim.Simulator&hl=en_IN	Topic-wise (Physics, Chemistry, Biology related topics as specific heat capacity, Resistance, Force and extension Electrolytes, temperature change Enzymes, Photosynthesis etc.)	Include simulations	Required Android 8.0 & up Download size-27.10 MB Version-1.3.2 Released on-126/08/2020 Updated on-10.02.2026	English	2.8	Science practical Simulator	India	Partially free
12	**Lab4U**	Physics, Chemistry Science https://ftp.lab4u.co/en/home/	Topic-wise (Physics and chemistry topics aligned with educational curriculum	·Allow for experiments in real-time Use smartph	Required Android 8.0 & up Download size-51.54 MB Version-3.2.10 Released on-06/08/2014	Multilingual (multiple languages	3.6	Lab4U	Chile	Paid (Often a paid app or requi

			for class 9,10,11,12)	one sensors to turn them into tools for experimentation	· Updated on- 06.05.2026	to cater to diverse student populations globally)				res a subscription)
13	**MEL Science: A Science Lab Apps**	Physics, Chemistry Science https://play.google.com/store/apps/details?id=com.melscience.melchemistry&hl=en_IN	Topic- wise (covers a wide range of science related topics, focusing primarily on chemistry and physics aligned with class 9,10,11,12 syllabus)	· App-based format, offering interactive experiments and educational content. ·Interactive simulations and virtual experiments	Required Android 6.0 & up Download size- 72.72 MB Version-2.66.7 Released on- 02/06/2015 · Updated on- 08.05.2026	Multilingual, with English as a primary language	4.2	MEL Science	United Kingdom	Typically a subscription-based service.
14	**SimuLab**	https://play.google.com/store/apps/details?id=com.simulab.student	Aligned content of class 9,10,11,12 of CBSE and Odisha board Broad range of scientific disciplines, including physics, chemistry, biology	· Relies on advanced simulation technologies to provide realistic and immersive experiences often leveraging capabiliti	Required Android 10 & up. Download size- 44.11 MB Version-3.8 Released on- 05/09/2022 · Updated on- 09.09.2024	Multiple languages	4.6	Immersivevision Technology	India	Usually provides a free version with possible in-app purchases.

				es like augmented reality (AR) or virtual reality (VR) for enhanced interactivity						
15	**Chemistry & Physics simulation**	Science https://play.google.com/store/apps/details?id=org.kiwix.kiwixcustomphet	Topic-wise (150 interactive simulations to explore a wide range of science concepts)	· Includes interactive simulations · Game like environment	Required Android 7.1 & up Download size- 94 MB Version-2023-03 Released on- 19/06/2016 Updated on- 05.03.2026	Multilingual	4.7	Kiwix Team & University of Colorado Boulder	USA	Paid
16	**VR Science Lab**	Science https://play.google.com/store/apps/details?id=com.abacus.professormaxwellsciencelab	Topic-wise (chemical reactions, sound waves and acidity)	Integrated AR and VR Compatibility	iPhone Requires iOS 11.0 or later. iPad Requires iPadOS 11.0 or later. iPod touch Requires iOS 11.0 or later. Mac Requires macOS 11.0 or later and a Mac with Apple M1 chip or later. . Required Android 7.1 & up Download size- 1 GB Version- 1.3.3 Released on- 19/06/2016 Updated on- 03.07.2024	English	4.1	ABACUS BRANDS, Inc	United States	Free
17	**Labster**	Biology, Chemistry, Physics https://play.goo	High school chemistry, Biology and Physics	Story based and immersiv	Required Android 9.0 & up Download size- 49.72	Multilingual (Sup	4.5	LabsterApS	Denmark	Paid

		gle.com/store/apps/details?id=com.labster.mobile.standalone	related to class syllabus	e science simulations. Labster is a high-fidelity simulation platform designed to provide immersive, interactive experiences for learning in science and related fields. The degree of simulation in Labster is quite advanced,	Version-7.24.0 Released on- 23/03/2022 Updated on- 22.10.2025	ports multiple languages including English)				
18	**Molecular Workbench**	Science including Physics, Chemistry, Biology, Nanotechnology etc. http://mw.concord.org/modeler/download.html	Topic-wise	Includes simulations Students and teacher can create their own simulations Simple user interface	Standard Edition (J2SE) v1.5 or higher version computer has at least 128 MB of RAM · Download size- 1.2 MB · Version- N/A · Released on- 2000 · Updated on- regular	English	Not given	The Concord Consortium	USA	Free

19	**Scholarlab**	various subjects – physics, chemistry and biology https://scholarlab.in/	Topics related to class 6-12	Game based 3D interactive Simulation	Required Android 5.1 & up Download size- 49.63 MB Version-4.5.13 Released on- 08/10/2020 Updated on- 17.03.2025	English	3.8	Scholarlab Technologies Pvt. Ltd.	India	Paid
20	**Science school Lab Experiments**	Science subjects – physics, chemistry https://play.google.com/store/apps/details?id=com.science.school.lab.experiment.games&hl=en_IN	High School related physics, chemistry topics	Game based 3D interactive Simulation	Required Android 5.1 & up Download size- 48.99 MB Version-1.1.5 Released on- 25/01/2022 Updated on- 30.05.2025	English	3.9	Jeego Gaming	India	Paid
21	**Lab.Hacks Dilution Calculator**	Science subjects – physics, chemistry https://play.google.com/store/apps/details?id=com.chrostudios.labhacks	Topic-wise content based on Science, Biology, Chemistry, Physics	Simulation, tools, calculators and libraries	Required Android 8.0 & up Download size- 38 MB Version-1.2.77 Released on- 26/12/2018 Updated on- 23.08.2025	English	4.8	Lab.hacks GmbH	Germany	Free download but offers in-app purchases

4.2 Discussion & Analysis

The analysis of Science-related Virtual Science Lab Applications (VSLAs) based on technical feasibility, interface type, language, rating, developer profile, origin country and cost reveals significant trends in the current landscape of digital science education tools.

In terms of technical feasibility, most applications demonstrate strong adaptability across devices, with compatibility ranging from Android-based smartphones (minimum requirements typically between Android 5.0 to 10 and above) to desktops and web browsers. Applications such as PhET Interactive Simulations and Labster stand out by offering both online and offline access, along with cross-platform compatibility (Windows, macOS, Android, iOS), thereby enhancing usability in diverse educational settings. However, advanced applications incorporating AR/VR technologies demand higher hardware specifications, including VR headsets or high-end devices, which may limit accessibility in low-resource environments.

From a visualisation perspective, the majority of apps rely on simulations, animations and interactive models. Several platforms, including Labster and PraxiLabs, provide immersive 3D and VR-based environments, enabling experiential and inquiry-based learning. Game-based and sensor-based applications (e.g., those

using smartphone sensors for real-time experiments like Lab4U) further enhance engagement and practical understanding.

Regarding interface type, there is a balanced distribution between web-based platforms and mobile applications, with many tools supporting both. Web-based interfaces are particularly advantageous for institutional and classroom use, while mobile apps offer flexibility for self-paced and remote learning. Some advanced platforms also extend to VR/MR interfaces, indicating a shift toward immersive learning ecosystems. Some of these Apps are in Gaming version hence becomes more interactive and interesting for students to learn with these Apps.

In terms of language accessibility, a notable strength is multilingual support. Applications developed under initiatives such as those by the Ministry of Education, Government of India provide regional language options (Hindi, Kannada, Malayalam, Marathi, Tamil), promoting inclusivity. Similarly, platforms like PhET Interactive Simulations support extensive translation (up to 95 languages), making them globally accessible. However, several applications still rely solely on English, which may restrict usability among non-English-speaking learners.

The user ratings of the applications generally fall within the moderate to high range (approximately 3.5 to 4.8), reflecting positive user engagement and satisfaction. High-rated applications such as Lab.hacks (4.8) and PhET Interactive Simulations (4.5+) indicate strong usability and educational value, whereas lower-rated apps may face challenges in interface design, stability, or content quality.

From the developer and origin perspective, a significant proportion of the applications originate from India, reflecting growing national efforts toward digital education and virtual labs. Contributions from countries such as the USA, United Kingdom, Germany, Chile, Denmark and Egypt indicate a globally distributed development ecosystem. Institutions like the University of Colorado Boulder and organizations such as The Concord Consortium highlight the role of academic and research bodies in developing high-quality educational tools.

Finally, regarding cost and accessibility, a mixed model is evident. Many applications are free or offer basic features at no cost (especially those supported by government or educational institutions), while others like Labster and MEL Science operate on subscription-based models. Freemium approaches (free download with in-app purchases) are also common, balancing accessibility with sustainability.

Overall, the analysis indicates that Science VSLAs are evolving toward highly interactive, immersive and accessible learning tools. While strengths include technological diversity, multilingual support and global participation, challenges remain in terms of hardware dependency, cost barriers for premium platforms and uneven language inclusivity.

5. Conclusion

This study provides a systematic analysis of virtual lab applications in science education. The comparison of these 21 virtual lab and science learning apps shows a clear shift toward interactive, simulation-based education aligned with school curricula (especially CBSE and State Boards). Apps like OLabs, DIKSHA, Embibe and ZeroSciencelab stand out for being free, curriculum-aligned and accessible in multiple Indian languages, making them highly suitable for large-scale classroom integration. Meanwhile, global platforms such as PhET, Labster and MEL Science offer high-quality, immersive simulations and advanced visualizations, often incorporating AR/VR elements, but are typically paid or subscription-based. Most Apps are technically feasible on standard Android devices, though some advanced platforms require higher OS versions, larger storage or specialized hardware, which may limit accessibility in low-resource settings.

Overall, the ecosystem reflects a balance between accessibility and sophistication: Indian-developed apps prioritize inclusivity, affordability and syllabus alignment, while international apps emphasize innovation, realism and immersive

learning experiences. Language support is generally strong, with many apps offering multilingual interfaces, though some remain English-only. Ratings indicate generally positive user reception, especially for apps combining ease of use with meaningful interactivity. For effective adoption in education systems, a blended approach-leveraging free, locally relevant tools alongside selective use of advanced premium platforms-would provide the most comprehensive and equitable digital science learning experience. The proposed classification framework contributes to a better understanding of virtual lab ecosystems and supports informed decision-making in educational contexts.

6. Recommendations

Incorporating assessment and feedback mechanisms can improve the effectiveness of virtual labs, while standardized classification systems ensure consistency in content organization.

Integration with learning management systems can enhance accessibility and usability for learners and educators. Additionally, developing immersive and remote labs can make learning more interactive and engaging.

7. Limitations

The study is limited to selected platforms and a small number of apps, which may affect the generalizability of the findings. Additionally, App ratings and updation may change over time and content classification may involve a degree of subjectivity.

8. Scientific Relevance

This paper contributes to the field of science education by providing a comprehensive understanding of virtual laboratory applications and their potential role in enhancing secondary-level science learning. The study highlights the educational, pedagogical and technical characteristics of virtual lab applications, thereby offering valuable insights into their usefulness for improving conceptual understanding, experimental learning and laboratory skill development in Physics, Chemistry and Biology. By examining features such as technical feasibility, accessibility, language, developer information, ratings, cost and usability, the study establishes a structured framework for evaluating digital learning tools in science education. The findings of the study may support educators, researchers, curriculum developers and policymakers in selecting effective virtual laboratory resources and promoting the integration of technology-based learning environments in school science education.

9. Future Scope

The study can be expanded by incorporating a larger dataset and conducting quantitative validation to strengthen the findings. Future research should also explore user experience and learning outcomes.

10. Delimitation

- Only Google search engine, Google play store, Apple App store & Windows App store have been used to search the apps for the present study.
- Only 30 keywords have been used to search the content of Virtual Lab Apps on the internet.
- Search keywords have been used only in English.
- The applications are aligned with content that largely corresponds to topics covered at the Indian secondary education level.

Declaration on the Use of AI

This paper was prepared with the assistance of ChatGPT, a language model developed by OpenAI, which was used for refining language.

References:

Akpınar, E. (2014). The use of interactive computer animations in science teaching: A review of the literature. Procedia - Social and Behavioral Sciences, 152, 146–150. https://doi.org/10.1016/j.sbspro.2014.09.169

Alsharif, Abdellatif. (2024). Virtual Simulation Lab Experiments versus Conventional Experiments in Teaching Physics - Comparative Study. International Journal of Education. 16. 34. 10.5296/ije.v16i1.21461.

Asiksoy, Gulsum. (2023). Effects of Virtual Lab Experiences on Students' Achievement and Perceptions of Learning Physics. International Journal of Online and Biomedical Engineering (iJOE). 19. 10.3991/ijoe.v19i11.39049.

Elmoazen, R., Saqr, M., Khalil, M., & Wasson, B. (2023). Learning analytics in virtual laboratories: A systematic literature review of empirical research. Smart Learning Environments, 10, Article 23. https://doi.org/10.1186/s40561-023-00244-y

Fridman, E. (2014). Virtual laboratories in science education: Trends and perspectives. International Journal of Online Engineering, 10(4), 14–18. https://doi.org/10.3991/ijoe.v10i4.3722

Hakim, A., Liliasari, L., Kadarohman, A., & Syah, Y. M. (2016). Improvement of student critical thinking skills with the natural product mini project laboratory learning. Journal of Turkish Science Education, 13(2), 54–66.

Hawkins, I., & Phelps, A. J. (2013). Virtual laboratory use in secondary science education: A review of the literature. Journal of Science Education and Technology, 22(3), 298–312.

Karacop, A., & Doymus, K. (2013). Effects of animation and cooperative learning on students' understanding of chemical bonding. Journal of Science Education and Technology, 22(2), 186–203.

Li, X., & Liang, Y. (2024). Effectiveness of virtual laboratory in engineering education: A meta-analysis. PLOS ONE, 19(12), e0316269. https://doi.org/10.1371/journal.pone.0316269

Ma, J., & Nickerson, J. V. (2006). Hands-on, simulated and remote laboratories: A comparative literature review. ACM Computing Surveys, 38(3), Article 7. https://doi.org/10.1145/1132960.1132961

Mahendra, I Gede Budi and Killis, B. (2026). Impact of Virtual Laboratory-Assisted Microlearning on Students' Motivation, Engagement and Academic Success. Journal of Learning for Development 12(1), 2025, 1-16. https://files.eric.ed.gov/fulltext/EJ1465550.pdf

Makransky, G., & Petersen, G. B. (2021). The Cognitive Affective Model of Immersive Learning (CAMIL): A theoretical research-based model of learning in immersive virtual reality. Educational Psychology Review, 33(3), 937–958. https://doi.org/10.1007/s10648-020-09586-2

Mila Dodevska, Eftim Zdravevski, Ivan Chorbev, Magdalena Kostoska, Frederico Branco, Paulo Jorge Coelho, Ivan Miguel Pires, Petre Lameski.(2025).Virtual reality as a learning tool: Evaluating the use and effectiveness of simulation laboratories in educational settings. Social Sciences & Humanities Open. Volume 12,101742,ISSN 2590-2911. https://doi.org/10.1016/j.ssaho.2025.101742.

Rajendran, L., & Divya, V. (2010). Virtual laboratories in education: A study. International Journal of Engineering Science and Technology, 2(6), 2173–2178.

Raman, R., Achuthan, K., Nair, V. K., & Nedungadi, P. (2022). Virtual laboratories—A historical review and bibliometric analysis of the past three decades. Education and Information Technologies, 27, 11055–11087. https://doi.org/10.1007/s10639-022-11058-9

Rosli, R., & Ishak, N. A. (2024). Integration of virtual labs in science education: A systematic literature review. Jurnal Pendidikan Sains Dan Matematik Malaysia, 14(1), 81–103. https://doi.org/10.37134/jpsmm.vol14.1.8.2024

Shivam, S., & Wagoner, K. (2020). How well do remote labs work? A case study at Princeton University. arXiv. https://arxiv.org/abs/2008.04499

Shah, Syed Faisal Abbas; Mazhar, T.; Shahzad ,Tariq; khan,Muhammad Amir; Ghadi Y. & Hamam H.(2024)Integrating educational theories with virtual reality: Enhancing engineering education and VR laboratories. Social Sciences & Humanities Open. Volume 10. 101207, ISSN 2590-2911. https://doi.org/10.1016/j.ssaho.2024.101207.

Tatira, Benjamin & Mshanelo, Thembelani. (2024). The impact of virtual laboratories on the academic performance of grade 12 learners in impulse and momentum. Edelweiss Applied Science and Technology. 8. 4150-4157. 10.55214/25768484.v8i6.2909.

Official websites of Apps

OLabs. (2023). OLabs app. Google Play Store. https://play.google.com/store/apps/details?id=in.edu.onlinelab.olabs

DIKSHA. (2018). DIKSHA app. Google Play Store. https://play.google.com/store/apps/details?id=in.gov.diksha.app

DIKSHA. (2018). Virtual labs. https://diksha.gov.in/virtuallabs.html

Embibe. (2022). Embibe experiments app. Google Play Store. https://play.google.com/store/apps/details?id=com.embibe.experiments.prod

University of Colorado Boulder. (2020). PhET simulations app. Google Play Store. https://play.google.com/store/apps/details?id=edu.colorado.phet.androidApp

PraxiLabs. (2023). About us. https://praxilabs.com/en/about-us

University of Colorado Boulder. (2023). PhET offline access. https://phet.colorado.edu/en/offline-access

EdzHub. (2021). Zero science app. Google Play Store. https://play.google.com/store/apps/details?id=com.edzhub.edzhub_zeroscience

Zero Science Lab. (2021). Zero Science Lab. https://zerosciencelab.in/

GameiZone. (2021). Science experiments in lab app. Google Play Store. https://play.google.com/store/apps/details?id=com.gameizonegmae.learnscienceexperimentsinlab

Google LLC. (2022) Tinkercad. Google Play. https://play.google.com/store/apps/details?id=com.tinkercad.www.twa

Rolling Panda. (2018). Science tricks experiment learning app. Google Play Store. https://play.google.com/store/apps/details?id=com.rollingpanda.science.tricks.experiment.learning.lab.school.college

Hazel Fun Studio. (2021). Girls high school science lab app. Google Play Store. https://play.google.com/store/apps/details?id=com.hazelfunstudio.girls.high.school.science.lab

Netlogo. (2018). Physics Lab https://play.google.com/store/apps/details?id=com.civitas.quantumphysics

Kids Games Factory. (2019). Science experiments lab app. Google Play Store. https://play.google.com/store/apps/details?id=com.kidsgamesfactory.science.experiments.lab

SciPracSim. (2020). Simulator app. Google Play Store. https://play.google.com/store/apps/details?id=com.SciPracSim.Simulator

Lab4U. (2014). Lab4U home. https://ftp.lab4u.co/en/home/

MEL Science. (2015). MEL Chemistry app. Google Play Store. https://play.google.com/store/apps/details?id=com.melscience.melchemistry

SimuLab. (2022). SimuLab student app. Google Play Store. https://play.google.com/store/apps/details?id=com.simulab.student

Kiwix. (2016). Kiwix custom PhET app. Google Play Store. https://play.google.com/store/apps/details?id=org.kiwix.kiwixcustomphet

Abacus. (2016). Professor Maxwell's science lab app. Google Play Store. https://play.google.com/store/apps/details?id=com.abacus.professormaxwellssciencelab

Labster. (2022). Labster mobile app. Google Play Store. https://play.google.com/store/apps/details?id=com.labster.mobile.standalone

Concord Consortium. (2000). Modeler download. http://mw.concord.org/modeler/download.html

ScholarLab. (2020). ScholarLab. https://scholarlab.in/

Science School Lab. (2022). Science experiment games app. Google Play Store. https://play.google.com/store/apps/details?id=com.science.school.lab.experiment.games

Chro Studios. (2022). Lab hacks app. Google Play Store. https://play.google.com/store/apps/details?id=com.chrostudios.labhacks