

VIRTUAL LABS IN SCIENCE EDUCATION: A CORRELATIONAL STUDY OF STUDENTS' PERCEPTION IN RELATION TO STREAM, ACADEMIC ACHIEVEMENT AND INTEREST

Ms. Sonika Devi¹, Dr. Mohan Galgotra², Ms. Sheetal Khajuria³, Dr. Ana Bali⁴, Dr. Anuradha Rani⁵

¹Research scholar, Department of Educational Studies, Central University of Jammu, India

²Assistant Professor, Department of Educational Studies, Central University of Jammu, India

³Research Scholar, Department of Educational Studies, Central University of Jammu, India

⁴Assistant Professor, Department of Education, University of Jammu, India

⁵Assistant Professor, Centre for Distance & Online Education, University of Jammu, India

Abstract

The use of Virtual Laboratories (VLs) in science education has become increasingly important because they improve understanding, accessibility, and engagement among learners. While earlier research focused mainly on students' achievements and attitudes, there are few studies that examine how students perceive Virtual Laboratories and how this affects their interest in science. The present study aimed to (i) assess students' level of perception toward VLs, (ii) examine their level of interest in science, (iii) determine differences in perception based on academic stream and achievement, and (iv) explore the relationship between perception and interest. A quantitative descriptive survey design was used for the study. The sample included 100 science students chosen through stratified random sampling from five higher secondary schools of Jammu district of Jammu & Kashmir. Data were collected using a self-made five-point Likert scale that measured perception across five dimensions: perceived usefulness, effort expectancy, motivation and engagement, attitude and preference, and content delivery. A self structured interest scale was also included. Statistical methods such as percentage analysis, t-test, ANOVA, and Pearson's correlation were applied. The findings showed that most students had high to very high levels of perception about virtual laboratories and interest in science. A strong positive correlation ($r = 0.617$, $p < .01$) was found between students' perception towards virtual laboratories and interest in science. Significant differences in perception were noted across academic streams and levels of interest, but no significant difference was found regarding academic achievement. The study concludes that a positive perception of virtual laboratories greatly improves students' interest in science, emphasizing the teaching role of integrating virtual lab technology in higher secondary science education.

Keywords: Virtual Labs, Science Education, Correlational, Perception, Stream, Academic achievement, Interest

1. Introduction

Learning happens through education, which helps people gain knowledge, skills, beliefs, and habits. Educational methods have changed a lot over time. We have moved from traditional classroom learning to more technology-based approaches. Today, education often takes place outside the usual classroom, thanks to digital tools that improve accessibility and engagement. In science education, hands-on experiments are crucial for understanding basic concepts. Technology plays a key role in

teaching and learning, helping students grasp important ideas. Yet, many schools face challenges like limited lab infrastructure, inadequate equipment, safety issues, time limits, and high maintenance costs. These problems often restrict students' chances for repeated experiments and a deeper understanding of concepts.

Virtual laboratories have surfaced as an innovative way to address these challenges. Virtual labs are digital platforms that simulate real lab environments and let students conduct experiments in an interactive and safe setting. They allow learners to repeat experiments as needed, visualize abstract processes like molecular interactions, and get immediate feedback. This encourages hands-on and self-directed learning. Along with understanding concepts and developing skills, students' interest in science and motivation to take part in hands-on activities are important outcomes of laboratory instruction. Virtual laboratories eliminate issues related to safety, cost, and time. They also offer rich, interactive environments that can spark curiosity and maintain interest in learning science. In simulation-based settings, students can explore phenomena over and over, get immediate feedback, and visualize processes that are usually invisible. These elements together create a more engaging experience that builds confidence. As a result, virtual labs are a promising tool for increasing higher secondary science students' interest in science and experimentation.

In science education, practical exposure is crucial for grasping reactions, molecular behavior, equilibrium processes, titration techniques, and electrochemical changes. Unfortunately, handling hazardous chemicals, limited lab hours, and safety rules often limit hands-on activities. Virtual laboratories help break down these barriers by offering safe, affordable, and flexible experimental environments (Tatli & Ayas, 2013; Potkonjak et al., 2016). Research shows that virtual labs improve understanding of concepts, engagement, and academic success while reducing anxiety for learners (Zacharia, 2015).

Perception plays an important role in science learning. It affects how students interpret, evaluate, and respond to new teaching methods like Virtual Laboratories (VLs). Students' perceptions impact their acceptance, engagement, and willingness to incorporate technology into their studies. When learners see a tool as useful, easy to use, and helpful for their academic goals, they tend to have positive attitudes and stay engaged longer. The Technology Acceptance Model (TAM), proposed by Fred Davis in 1989, suggests that how much users accept technology depends mainly on two factors: perceived usefulness and perceived ease of use. In education, if students find virtual labs helpful for better understanding concepts and making complex scientific processes simpler; they tend to view them positively. This kind of perception encourages students to adopt and keep using these tools. Research in science education backs up this idea. Tatli and Ayas (2013) found that students who used virtual chemistry labs developed positive views about their effectiveness in enhancing understanding and reducing laboratory anxiety. In a similar study, Sesen and Tarhan (2013) reported that inquiry-based virtual lab applications improved students' perceptions and attitudes toward topics in electrochemistry.

Interest is an important emotional factor in science learning. It greatly affects students' engagement, persistence, understanding of concepts, and overall academic success. Hidi and Renninger (2006) state that interest develops over time. It starts with situational interest, which is triggered by things in the environment, and evolves into individual interest, a lasting personal trait. Technology-driven

settings like virtual labs can spark situational interest through interactive simulations, visual aids, and instant feedback. This can eventually lead to a lasting individual interest in science.

So far, most of the research on virtual labs (VLs) has centered on achievement, understanding concepts, and attitudes. However, there is an increasing need to explore how interested students are in using VLs as part of their regular science learning. It's important to see how this interest connects to their engagement and motivation. This study aims to fill that gap by looking at students' views on VLs and their interest in including virtual experiments in their science curriculum.

1.1. About Virtual Labs:

Virtual laboratories provide remote access to experimental setups and simulation-based experiences, mainly in science and engineering. They significantly improve education while reducing the risks associated with traditional labs, including resource limitations and safety hazards. The idea of virtual laboratories emerged in the early 1990s, coinciding with advancements in computer technology and the internet. By the early 2000s, virtual labs that replicated real laboratory experiences became essential in educational institutions. These platforms allowed students to conduct experiments remotely, enhancing learning accessibility and flexibility.

1.2. Virtual Labs in India:

In 2009, the Indian government's Ministry of Education (MoE) launched Virtual Labs as part of the National Mission on Education through ICT (NMEICT). This initiative aims to provide remote access to high-quality lab simulations, addressing the challenges associated with laboratory infrastructure, especially in rural and remote areas. In 2010, the government made the program more inclusive and accessible by adding regional languages and opening it to schools and universities. During the COVID-19 pandemic in 2020, platforms like DIKSHA and other ed-tech tools integrated virtual lab simulations to support continuous learning during lockdowns, significantly accelerating the adoption of virtual labs. The pandemic also highlighted the need for digital learning resources, underscoring the importance of VLs in maintaining continuity in science education (Bai et al., 2021). Virtual Labs have transformed science education by offering a cost-effective and accessible learning platform for students worldwide. In India, especially in Jammu and Kashmir, they help bridge the gap between schools with limited resources and modern educational tools, ensuring that students can access quality scientific learning regardless of their location. The National Education Policy (NEP) 2020 emphasizes the importance of technology driven practical learning to ensure fair access to high-quality education across all regions, especially in less privileged areas like the Jammu division (MHRD, 2020).

2. Literature Review:

Many previous studies related to virtual labs reported that exposure to virtual laboratories improved students' chemistry self-efficacy and conceptual knowledge (Pyatt and Sims, 2012). Studies also show that virtual laboratories improve students' academic achievement and understanding of concepts (Tatli & Ayas, 2013; Zacharia, 2015). A meta-analysis by Bai et al. (2021) found that VLs significantly boost learning outcomes in chemistry education. Research also points to better motivation and inquiry skills due to VL use (Husnaini & Chen, 2019). Reginald (2023) reported that virtual laboratories support self-regulation and learner autonomy. When it comes to interest, inquiry-based virtual labs greatly enhance students' engagement and positive attitudes toward learning

chemistry (Tatli & Ayas, 2013). Davenport et al. (2018) observed that virtual laboratories positively influenced students' academic achievement and attitudes compared to traditional methods. Recent reviews (Sapriati et al., 2023) highlight that virtual labs positively affect students' self-regulated learning and sustained interest. Wright (2023) emphasized the importance of virtual lab resources in online science teaching and provided examples of interactive platforms that support laboratory instruction. Kolil and Achuthan (2024) concluded that integrating virtual labs in science (chemistry) education enhances engagement, laboratory skills, and links with curriculum goals.

However, there is limited evidence about how students perceive VLS based on their academic stream and achievement, especially in the Indian higher secondary context.

3. Objectives of the study

1. To study the perception of science students in higher secondary schools toward the use of virtual labs.
2. To study the levels of perception of science students toward Virtual Laboratories.
3. To study the levels of interests of science students toward science subject.
4. To study the relationship between students' perception towards Virtual Laboratories and their level of interest towards science.
5. To study whether there is a significant difference in the perception of science students towards Virtual Laboratories in relation to their level of interest.
6. To examine whether there is a significant difference in the perception of science students towards Virtual Laboratories in relation to their academic stream.
7. To investigate whether there is a significant difference in the perception of science students towards Virtual Laboratories in relation to their academic achievement.
8. To recommend educational implications based on the outcomes of the current study.

4. Hypotheses of the Study

1. There will be no significant relationship between students' perception towards Virtual Laboratories and their level of interest towards science.
2. There will be no significant difference in the perception of science students towards Virtual Laboratories in relation to their level of interest.
3. There will be no significant difference in the perception of science students towards Virtual Laboratories in relation to their academic stream.
4. There will be no significant difference in the perception of science students towards Virtual Laboratories in relation to their academic achievement.

5. Methodology Used: To collect objective, numerical data that aligned with its objectives, this study employed a quantitative approach.

5.1. Design of Research

A quantitative, descriptive design based on surveys was used. Five higher secondary schools of Jammu district of UT- Jammu & Kashmir was randomly chosen for the study.

5.2. Population and Sampling: All the students enrolled in the science stream of higher secondary schools in the Jammu district of Jammu & Kashmir was considered as the population of the study.

• **Sampling Methodology:** The students enrolled in science stream of higher secondary schools in

the Jammu district of UT-Jammu & Kashmir was chosen as a sample of the study by using simple random sampling technique.

- **Sample Size:** Only five schools out of 78 higher secondary schools in the Jammu district of J&K was chosen from which 10 students each of medical and non medical stream was chosen for the study.

- **Participant Category:** Higher secondary school students enrolled in the science stream considered as the sample.

5.3. Data Collection Method: The researcher used a self-constructed Likert-scale to gather data. The present study was designed to find out the relationship between the perception of science students towards virtual laboratories in relation to their level of interest, academic stream and academic achievement. Taking into consideration these objectives, the present study employed a descriptive survey method in which different statistical technique was employed for fulfilling the objectives and verifying of the hypotheses proposed.

5.4. Data Collection Procedure

For the collection of data on perception of science students towards virtual labs and level of interest, two self constructed five point likert scales i.e., Perception towards Virtual Labs and Interest towards Science Subject was standardized and employed. Once the chosen schools gave their consent, the study was conducted. Students in the science stream were given questionnaires to fill out. All participants received a comprehensive description of the objectives and purpose of the study prior to the distribution of the questionnaires. Participants received guarantees that their answers would be kept private and used exclusively for study.

5.5. Analysis of Data

For data analysis, descriptive statistics as well as inferential statistical methods i.e., Percentage, Mean, Standard Deviation, Coefficient of Correlation was employed to analyse the data gathered from the surveys.

5.6. Moral Points to Remember

- The chosen schools gave their consent.
- Participants received assurances that the survey would carefully protect their privacy.

6. Results and Discussions

Objective 2. To study the levels of perception of higher secondary science students toward the use of virtual labs.

In order to study the percentage wise distribution of level of perception of science students towards virtual lab, percentage was applied which is represented graphically in Figure 1.

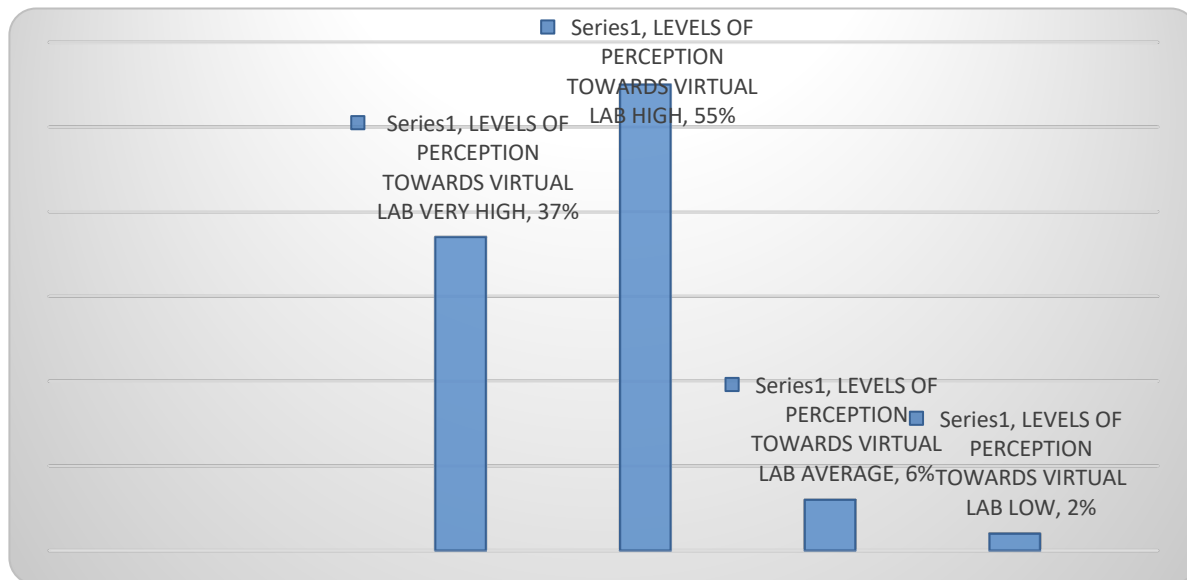


Figure 1: Percentage distribution of students with reference to level of perception

As observed from the figure that out of the total sample of 100 higher secondary school students of science stream 37% students are found to have very high level of perception, 55% students are found to have to high level of perception, 6% of students are found to have average level of perception followed by only 2% of students have low level of perception as shown graphically. On the basis of the above results it can be analyzed that students showed a high perception towards use of Virtual labs in their science subject.

Objective 3: To study the levels of higher secondary students towards interest in science subject.

In order to study the percentage wise distribution of level of students towards interest in science subject, percentage was applied which is represented graphically in Figure 2.

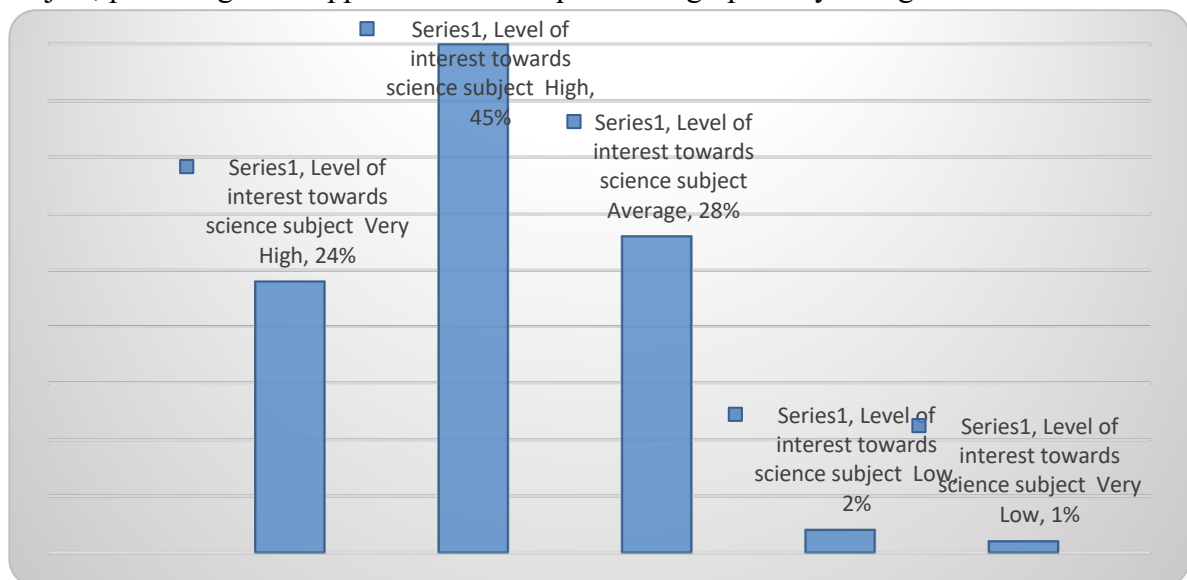


Figure 2: Percentage distribution of students with reference to level of interest

As observed from the figure that out of the total sample of 100 higher secondary school students of science stream 24% students are found to have very high level of interest towards science subject, 45% students are found to have high level of interest towards science subject, 28% of students are

found to have average level of interest in science subject followed by 2% of students have low level of interest in science subject and only 1% of students are found to have very low level of interest towards science subject as shown graphically. On the basis of above figures it can analyze that majority of the sample of the study shown a high level of interest towards science subject.

Objective 4: To study the relationship between student’s perception towards virtual laboratories and interest towards science.

Hypothesis 1: There will be no significant relationship between student’s perception towards virtual laboratories and interest towards science.

Table 1: Showing Co-efficient of correlation between students’ perception towards virtual laboratories and interest towards science subject.

Variables	N	r
Perception towards Virtual Labs	100	0.617**
Interest towards Science subject		

**significant 0.01 level

As per table 1, it is evident that the correlation coefficient between perception toward virtual labs and interest towards science subject is 0.617, which is positive and significant at 0.01 level. Thus, the null hypothesis that there is no significant relationship between perception towards virtual labs and interest towards science subject of higher secondary school students is rejected. It shows that perception of higher secondary school students towards virtual labs and interest towards science subject were positively and significantly correlated.

Objective 5: To study the significant difference in perception of higher secondary school students towards virtual laboratories in relation to their interest towards science subject.

Hypothesis 2: There will be no significant difference in perception towards virtual laboratories in relation to their interest towards science subject.

Table 2: Showing the significant mean difference in the perception of higher secondary school students towards virtual labs in relation to their interest towards science subject.

Variable	Stream	N	Mean	S.D	‘t’-value	P-value
Interest towards science subject	Very High	24	128.10	19.01	1.98*	.050
	High	45	113.05	15.72		

*Significant at 0.05 level of confidence.

As per table 2, the obtained t-value for perception of secondary school students towards virtual labs in relation to interest towards science subject is found to be 1.98, which is significant at 0.05 level ($p < 0.05$). Hence, the above stated null hypothesis is rejected at 0.05 level of significance and it is concluded that there is significant difference between higher secondary students who have very high interest towards science stream and low interest towards science with respect to their perception towards virtual labs. Based on the mean scores, it is also clear that higher secondary students who have very high interest towards science have high mean scores for perception towards virtual labs than students having high interest towards science.

Objective 6: To study the significant difference in perception of higher secondary school students towards virtual laboratories in relation to their academic stream.

Hypothesis 3: There will be no significant difference in perception of higher secondary school students towards virtual laboratories in relation to their academic stream.

Table 3: Showing the significant Mean Difference in the perception of higher secondary school students towards virtual labs in relation to their academic stream.

Variable	Stream	N	Mean	S.D	't'-value	P-value
Stream	Non-Medical	50	110.11	17.88	2.07**	.050
	Medical	50	102.95	16.13		

***Significant at 0.05 level of confidence.**

From the table 3, the obtained t-value for perception of higher secondary school students towards virtual labs in relation to different stream is found to be 2.07, which is significant at 0.05 level ($p < 0.05$). Hence, the above stated null hypothesis is rejected at 0.05 level of significance and it is concluded that there is significant difference between non-medical stream and medical stream higher secondary school students with respect to their perception towards virtual labs. Based on the mean scores, it is also clear that non-medical stream students have high mean scores for perception towards virtual labs than medical stream students.

Objective 7: To study the significant difference in perception of higher secondary school students towards virtual laboratories in relation to their academic achievement.

Hypothesis 4: There will be no significant difference in perception of higher secondary school students towards virtual laboratories in relation to their academic achievement.

Table 4: Showing the significant mean difference in the perception towards virtual labs in relation to their academic achievement.

Variable	Stream	N	Mean	S.D	't'-value	P-value
Academic Achievement	High	57	118.16	18.12	1.06	1.10
	Low	43	114.24	14.45		

As per table 4, the obtained t-value for perception of higher secondary school students towards virtual labs in relation to different stream is found to be 1.06, which is not significant at 0.05 level ($p < 0.05$). Hence, the above stated null hypothesis is accepted and it is concluded that there is no significant difference between high academic achievers and low academic achievers secondary school students with respect to their perception towards virtual labs. Based on the mean scores, it is also clear that there is a minimal difference in the mean scores of secondary school student's perception towards virtual labs.

7. Conclusion

In conclusion, the findings of the study contribute to the field of education by examining the influence of perception of students towards virtual labs, on their academic streams, academic achievement, and level of interest towards science subject. Considering the outcomes of the study it can be concluded that efforts should be made by the teachers and parents to improve the level of students' interest towards science subject. The study also found the positive impact of use of virtual labs on students' academic achievement based on which it can be concluded that students with high level of interest towards science subject led to higher academic achievement. On the other hand, guidance for the

students having low level of interest should be given to face difficulties in various academic tasks. They must have the belief that they are capable of accomplishing academic goals. Lack of interest on the part of students may lead to shortcomings or difficulties in carrying out academic tasks which were termed as cognitive negativity by Albert Bandura.

8. Recommendations

The present study is based on the perception of science students towards virtual labs and level of interest of students towards science subject of higher secondary school students, the findings show that students generally have a very positive perception of Virtual Laboratories. A significant number of students showed high and very high levels of perception, indicating that they see VLs as useful, engaging, and supportive tools for learning science. The study also found that students are quite interested in science, with most participants reporting high or very high levels of interest. Most significantly, there was a strong and statistically significant positive relationship between perception of Virtual Laboratories and interest in science ($r = 0.617$, $p < .01$). This means that students who find virtual labs useful, easy to use, and engaging tend to have a greater interest in science subjects. Therefore, perception plays an important role in shaping students' motivation to learn science. There were notable differences in perception between students in medical and non-medical streams, with non-medical students showing relatively higher perception levels. Additionally, students with very high interest in science had a significantly more positive view of Virtual Laboratories than those with lower interest. However, academic achievement did not significantly affect students' perceptions, suggesting that acceptance of VLs is not tied to previous academic performance. So, it is recommended that in educational institutions adequate efforts should be taken by the stakeholders to develop interest of students towards science subject to great extent. For this reason, group discussion and workshops should be conducted in the institutions. Teachers should make the students aware of their interest and should try to develop a positive attitude on their own level of interest as a result of which they can able to accomplish their goals on their academic ground. It should also be the duty of parents to know whether their children have positive confidence in their ability or not, and appropriate steps should be taken because academic achievement of the student plays pivot role to cope up with academic difficulties.

9. Educational Implications of the study

The findings of this study have several important implications for science teachers, curriculum developers, and policymakers seeking to enhance the quality and inclusivity of science education.

- 1. Pedagogical Integration:** Teachers should integrate virtual laboratories carefully into lesson plans to improve understanding and support theoretical instruction.
- 2. Blended Laboratory Model:** Schools should use a blended approach that combines physical and virtual laboratories. This method maximizes hands-on learning while ensuring safety and saving costs.
- 3. Teacher Training and Professional Development:** Schools should set up training programs to give teachers the skills they need for effective virtual lab integration.
- 4. Curriculum Reform:** Curriculum developers should include virtual laboratory components in science courses, making them a standard part of the curriculum rather than optional extras.

- 5. Policy-Level Investment:** Policymakers should invest in digital infrastructure, device access, and reliable internet service to ensure fair implementation, especially in areas with fewer resources.

References

- Adnan, M., & Anwar, K. (2020). Online learning amid the COVID-19 pandemic: Students' perspectives. *Journal of Pedagogical Sociology and Psychology*, 2(1), 45-51. <https://doi.org/10.33902/JPSP.2020261309>
- Alhashem, F., & Alfaiakawi, A. (2023). Technology-enhanced learning through virtual laboratories in chemistry education. *Contemporary Educational Technology*, 15(4), Article ep474. <https://doi.org/10.30935/cedtech/13739>
- Bai, H., Mo, S., & Lau, K. (2021). The effectiveness of virtual laboratories in chemistry education: A meta-analysis. *Educational Technology & Society*, 24(3), 45-60.
- de Jong, T., Linn, M. C., & Zacharia, Z. C. (2013). Physical and virtual laboratories in science and engineering education. *Science*, 340(6130), 305–308. <https://doi.org/10.1126/science.1230579>
- Elmoazen, R., Saqr, M., Khalil, M. *et al.* Learning analytics in virtual laboratories: a systematic literature review of empirical research. *Smart Learn. Environ.* **10**, 23 (2023). <https://doi.org/10.1186/s40561-023-00244-y>
- Husnaini, S. J., & Chen, S. (2019). Effects of guided inquiry virtual and physical laboratories on conceptual understanding, inquiry performance, scientific inquiry self-efficacy, and enjoyment. *Physical Review Physics Education Research*, 15(1), Article 010119. <https://doi.org/10.1103/PhysRevPhysEducRes.15.010119>
- Kolil, V. K., & Achuthan, K. (2024). Virtual labs in chemistry education: A novel approach for increasing students' laboratory educational consciousness and skills. *Education and Information Technologies*, 29, 25307–25331.
- Kurtz, M., Benabbou, A., Pons, C. *et al.* Collaboration in virtual and remote laboratories for education: A systematic literature review. *Intern. J. Comput.-Support. Collab. Learn* **20**, 549–603 (2025). <https://doi.org/10.1007/s11412-025-09454-7>
- Ministry of Human Resource Development. (2020). *National Education Policy 2020*. Government of India. https://www.education.gov.in/sites/upload_files/mhrd/files/NEP_Final_English_0.pdf
- Potkonjak, V., Gardner, M., Callaghan, V., Mattila, P., Guetl, C., Petrovic, V. M., & Jovanovic, K. (2016). Virtual laboratories for education in science, technology, and engineering: A review. *Computers & Education*, 95, 309–327. <https://doi.org/10.1016/j.compedu.2016.02.002>
- Reginald, G. (2023). Teaching and learning using virtual labs: Investigating the effects on students' self-regulation. *Cogent Education*, 10(1), Article 2172308. <https://doi.org/10.1080/2331186X.2023.2172308>
- Roda-Segarra, J. (2021). Virtual laboratories during the covid-19 pandemic: A systematic review. In: *2021 XI International Conference on Virtual Campus (JICV)* (pp. 1–4). <https://doi.org/10.1109/JICV53222.2021.9600344>
- Sapriati, A., Suhandoko, A. D. J., Yundayani, A., Abdul Karim, R., Mohd Adnan, A. H., &

Suhandoko, A. A. (2023). The effect of virtual laboratories on improving students' self-regulated learning: An umbrella systematic review. *Education Sciences*, 13(3), Article 222. <https://doi.org/10.3390/educsci13030222>

Tatli, Z., & Ayas, A. (2013). Effect of a virtual chemistry laboratory on students' achievement. *Educational Technology & Society*, 16(1), 159-170.

Zacharia, Z. C. (2015). The impact of interactive virtual labs on high school students' understanding of chemistry concepts. *Journal of Science Education and Technology*, 24(2), 161-175.