# A Descriptive Pilot Study of the Availability of Virtual Laboratories Among Intermediate Science Students

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## ABSTRACT

Virtual laboratories can support science education by providing interactive, technology-based practical learning experiences, particularly where traditional laboratory facilities are limited. This descriptive pilot study examined students' reported availability of virtual laboratory facilities in an intermediate college. Data were collected from 40 science students using a structured questionnaire and analyzed using descriptive statistics, including frequencies, percentages, mean, standard deviation, median, and score ranges. The availability scores ranged from 22 to 55, with a mean of 32.55 (SD = 7.62), indicating variation in students' reported availability of virtual laboratory facilities. Because the available dataset contains total availability scores only, this pilot report does not present empirical results for the separate accessibility dimension and does not test inferential hypotheses. The findings are preliminary and are intended to describe the sample and inform refinement of the research instrument and a larger study. Further work should collect item-level responses for both availability and accessibility, establish content validity and reliability, and use an adequately planned analysis to address broader research questions.

Keywords: Intermediate Students, Science Education, Virtual Laboratory, Availability, Descriptive Pilot Study.

## INTRODUCTION

Science education requires opportunities for the learners to observe phenomena, manipulate variables, conduct experiments, and interpret results. But many schools find it difficult to provide regular laboratory experiences due to lack of equipment, high maintenance costs, crowded classrooms, and safety concerns.

Virtual laboratories can complement traditional laboratory teaching. Students can perform simulated experiments through computers or mobile devices. They may provide flexible access, repeated practice, immediate feedback, and the opportunity to visualize processes that are hard to observe in a physical laboratory. Research on virtual laboratories in science education has examined their use in biology, chemistry, physics, engineering, and medicine.

The availability of virtual laboratories has increased, but this does not necessarily mean that they are used effectively. Availability may be affected by internet access, computers, electricity, software, and institutional support. Utilization may be affected by teachers' competence, students' digital skills, curriculum requirements, and perceived usefulness.

This study is reported as a descriptive pilot investigation of the availability of virtual laboratory facilities among intermediate science students. Although accessibility is important to effective virtual-laboratory use, the dataset analyzed for this report contains availability total scores only. Therefore, the present results are restricted to availability and do not claim to assess accessibility empirically.

# REVIEW OF RELATED LITERATURE

A comprehensive review of related literature is essential to establish the theoretical foundation of the present study and to identify research gaps concerning the availability and accessibility of virtual laboratories in Biological science education. Recent research on virtual laboratories spans multiple dimensions, including availability and accessibility, technological innovation, and the integration of artificial intelligence–based tools. The following subsections present a thematic review of relevant studies, aligned with the focus of the present investigation.

- **Kachi et al. (2025)** conducted a descriptive survey on the accessibility and availability of virtual laboratories in secondary schools in Likuyani, Kenya. The research found that institutional support and access varied by school. The study found the main barriers were lack of ICT resources, irregular use, deficiencies in teacher preparation, and lack of support and suggested better infrastructure, training, and oversight.

- **Elmoazen et al. (2021)** conducted a systematic review titled *Learning Analytics in Virtual Laboratories*, which integrated 21 papers published between 2015 and 2021. The majority of research was conducted in higher education, particularly in the field of medicine. According to the review, learning analytics in virtual laboratories were mostly based on student log files and were used to evaluate behavior, performance, activities, and perceptions. Additionally, it found that the area is currently small-scale, exploratory, and fragmented, underscoring the need for increased cooperation and clear standards in future study.

- **Peirson (2025)** examined students' experiences of virtual and traditional laboratories in science education, with particular attention to how learners perceive and engage with virtual laboratory environments. The study, conducted among A-level Chemistry students in Further Education, used questionnaires and semi-structured interviews to explore students' views and experiences. The findings revealed key themes related to reality, control, practical skills, theory, trust, and risk, suggesting that virtual laboratories can provide meaningful learning experiences that simulate traditional practical work. However, the study also highlighted gaps in empirical evidence concerning students' everyday experiences with virtual laboratories, particularly outside higher education. The limited research in Further Education, together with challenges such as funding and limited facilities, indicates the need for further investigation into the availability, accessibility, and educational use of virtual laboratories across diverse science education contexts.

- **Ge et al. (2025)** conducted a 14-week study published in *Scientific Reports* comparing the effectiveness of AI-enhanced virtual laboratories with traditional laboratory instruction in food microbiology education among 128 undergraduate students. The study found that the usage of AI-augmented virtual laboratories resulted in significant improvements in knowledge acquisition, practical skills development, and conceptual understanding, and achieved a 71.6% reduction in students' misconceptions. Using system interaction log files and learning analytics, the study identified three different user profiles (systematic explorers, targeted users, and minimal adopters) and found that a higher level of feature use was a strong predictor of better learning outcomes. The research further found it reduced the cost per student by 80.9%, and also extended the lab availability for 24/7 access, making it a highly scalable and cost-effective solution for resource-constrained educational institutions.

- **Widiarni et al. (2026)** utilized a Research and Development (R&D) framework based on the Borg and Gall model to address resource limitations in physics education through the design of a virtual reality (VR) learning medium. Utilizing the MilleaLab platform integrated with affordable hardware (VR Box), the study targeted the concept of Uniformly Accelerated Motion (GLBB) for high school students. Survey findings revealed a strong student demand for dynamic visualization, with 92% expecting VR to improve their grasp of abstract physics concepts. Following Pantelidis's guidelines for VR instructional design, the authors structured a semi-immersive, interactive 3D simulation featuring real-time graphical

feedback and audio narration. The study identified minimum smartphone hardware specifications (4 GB RAM and gyroscope support) as critical for optimal user experience. The research concluded that low-cost, smartphone-based VR offers a viable intervention to compensate for inadequate laboratory infrastructure and enhance conceptual learning in secondary science education.

## 3. Objectives of the Study

1. To describe the reported availability of virtual laboratory facilities among a pilot sample of intermediate science students.

2. To summarize the variation in students' total availability scores using descriptive statistics.

3. To identify methodological and instrument-development needs to be addressed before a larger study of availability and accessibility is conducted.

4. To provide preliminary evidence to inform refinement of the questionnaire and a subsequent full-scale study.

## 4. Research Questions

1. What are the reported availability scores for virtual laboratory facilities among the participating intermediate science students?

2. How are the total availability scores distributed in this pilot sample?

3. What instrument-validation and data-collection steps are needed before availability and accessibility can be evaluated in a larger study?

The present analysis is descriptive and exploratory. No null hypotheses are tested because the available data and stated pilot scope do not provide a specified inferential comparison or reference value against which to test them.

## 5. Operational Definitions

- **Intermediate Students:** Intermediate Students means the students of the Course that bridges School Education and Higher Education.

- **Science Education:** Science Education refers to the systematic teaching and learning of scientific concepts, principles, processes, and skills through appropriate instructional methods and learning experiences.

- **Virtual Laboratory:** A virtual laboratory is a computer-based learning environment that enables students to perform biological experiments and observe scientific processes through simulations without the use of physical equipment or live specimens.

- **Availability:** Measures the existence and supply of a resource.

- **Accessibility**: The ease with which a user can reach and use virtual laboratory platforms and related resources. Accessibility is part of the broader instrument framework but is not separately analyzed in the current dataset.

## 6. Variables of the Study

- **Independent Variable:** Virtual Laboratory

- Dependent variable for this pilot analysis: reported availability of virtual laboratory facilities.
- **Control Variables:** Age, prior knowledge, academic background

# METHODOLOGY

## 7.1 Research Design

The study employed a cross-sectional descriptive pilot survey design. Data were collected at one point in time without manipulating any variable. The pilot was intended to describe availability scores and inform improvements to the instrument and study procedures; it was not designed to establish causal effects or test inferential hypotheses.

## 7.2 Population and Sample

The population of interest comprised science students studying at an intermediate college. A purposive sample of 40 science students was selected from one intermediate college. The manuscript identifies the institutional affiliation of the researchers as Maulana Azad National Urdu University, Hyderabad, but the specific name and location of the participating intermediate college were not recorded in the supplied manuscript and must be added by the researcher before submission.

## 7.3 Research Tool

Availability and Accessibility of Virtual Laboratories Questionnaire (AAVLQ). The instrument framework includes two dimensions: availability (platforms, experiments, learning resources, institutional facilities and devices) and accessibility (access inside/outside the institution, internet connectivity, device access, ease of login/use, and convenient timing). However, the dataset analyzed in this report contains 20 availability items and availability total scores only; accessibility results cannot be reported from these data.

Scoring, validity and reliability: The questionnaire used a three-point response scale, with each item scored from 1 to 3 according to the response options provided on the administered questionnaire. The exact verbal labels for the three response categories should be reproduced exactly as they appeared on the questionnaire; they are not specified here because those labels were not provided in the manuscript materials. The total score is obtained by adding the item scores, after reverse-scoring any negatively worded items if applicable. The instrument's validity and reliability have not been established for the present study. No expert-based content-validity assessment or Cronbach's alpha analysis was conducted. These are limitations of the pilot study and should be addressed in a subsequent validation study using expert review and respondent-level item data. No validity or reliability coefficient is claimed in this manuscript

| Dimension | Possible Areas |
|---|---|
| **Availability** | Availability of virtual laboratory platforms, science/biology experiments, learning resources, institutional facilities, devices |
| **Accessibility** | Access inside/outside institution, internet connectivity, device accessibility, ease of login/use, availability at convenient time |

## 7.4 Data Collection Procedure

The researcher obtained permission from the concerned institutions before data collection. The participants were informed about the purpose of the study and assured that the information provided by them will be used only for research purposes. The questionnaire was then administered to the selected sample of science students during the specified period. The completed questionnaires were collected and checked for completeness before data analysis.

## 7.5 Data Analysis

The available data were analyzed descriptively using frequencies, percentages, mean, standard deviation, median, minimum, maximum, and percentiles. No inferential tests were conducted. Because this is a descriptive pilot study and no appropriate comparison groups or testable reference values were specified, the manuscript does not report hypothesis testing or claim statistical significance.

The analyzed questionnaire section consisted of 20 items related to availability and used a three-point response scale. Total scores were available for 40 respondents. Item-level responses and a separate accessibility score were not available in the dataset used for this report; consequently, accessibility statistics and internal-consistency reliability (Cronbach's alpha) could not be calculated from the information available. The validity and reliability of the questionnaire have not yet been established and are acknowledged as limitations.

## RESULTS AND DISCUSSION

### 8.1 Descriptive Statistics of Availability Scores

**Table 1: Descriptive Statistics of Virtual Laboratory Availability Scores (N = 40)**

| Statistic | Value |
|---|---|
| Number of respondents ($N$) | 40 |
| Minimum score | 22 |
| Maximum score | 55 |
| Mean | 32.55 |
| Standard Deviation | 7.62 |
| Median | 30.00 |
| 25th Percentile | 27.00 |
| 75th Percentile | 35.00 |

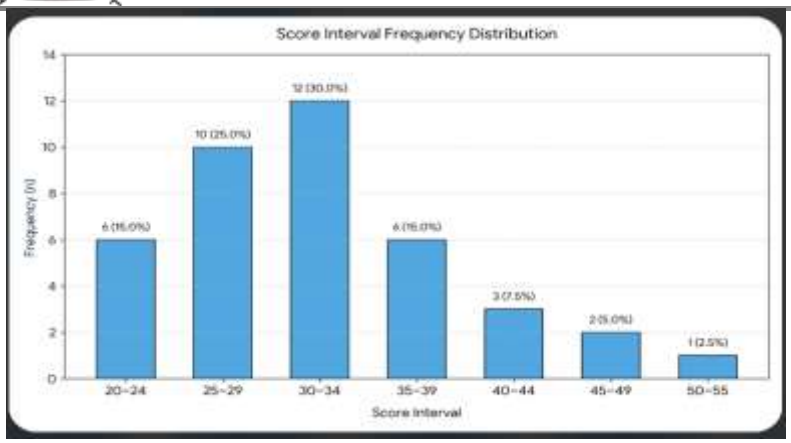
**Interpretation:**

Table 1 shows that the availability scores of the 40 respondents ranged from 22 to 55, indicating considerable variation in respondents' perceptions of the availability of virtual laboratory facilities. The mean score was 32.55, with a standard deviation of 7.62. The median score was 30, indicating that half of the respondents obtained scores below or equal to 30 and half obtained scores above or equal to 30. The difference between the minimum and maximum scores further indicates that the availability of virtual laboratory facilities was not perceived uniformly by all respondents.

### 8.2 Frequency and Percentage Distribution of Respondents by Score

To present the cross-sectional findings more clearly, the respondents' total scores are presented in score intervals below.

**Frequency and Percentage Distribution of Availability Scores (N = 40) Chart**




**Interpretation:**

The distribution shows that the largest proportion of respondents, 12 (30.0%), obtained scores between 30 and 34. A further 10 respondents (25.0%) scored between 25 and 29. Thus, 55% of the respondents obtained scores below 35. Only one respondent (2.5%) obtained a score between 50 and 55, while five respondents in total (12.5%) obtained scores of 40 or above. This indicates that relatively few respondents reported very high availability scores.

### 8.3 Overall Finding regarding Availability

The mean availability score of 32.55 provides an overall indication of the perceived availability of virtual laboratory facilities among the respondents. The findings demonstrate that availability was not uniformly high across the sample. A substantial proportion of respondents obtained relatively low-to-moderate scores, whereas only a small proportion obtained higher scores. The descriptive pilot study nature of the study means that these findings represent the status of virtual laboratory availability at the time of data collection. They should therefore be interpreted as a snapshot of the existing situation rather than evidence of change over time or an effect of an intervention.

### 8.4 Respondent-wise Availability Scores

**Table 3: Total Availability Scores of the 40 Respondents**

| Respondent | Score | Respondent | Score | Respondent | Score | Respondent | Score |
|---|---|---|---|---|---|---|---|
| **1** | 45 | **11** | 30 | **21** | 23 | **31** | 38 |
| **2** | 42 | **12** | 29 | **22** | 35 | **32** | 28 |
| **3** | 22 | **13** | 43 | **23** | 35 | **33** | 24 |
| **4** | 24 | **14** | 27 | **24** | 46 | **34** | 31 |
| **5** | 27 | **15** | 28 | **25** | 27 | **35** | 33 |
| **6** | 35 | **16** | 35 | **26** | 30 | **36** | 33 |
| **7** | 44 | **17** | 47 | **27** | 26 | **37** | 55 |
| **8** | 30 | **18** | 24 | **28** | 28 | **38** | 26 |
| **9** | 40 | **19** | 32 | **29** | 30 | **39** | 28 |
| **10** | 31 | **20** | 29 | **30** | 35 | **40** | 27 |

### 8.5 Major Findings

Based on the descriptive analysis, the following findings were obtained:

**Table 4: Summary of Major Findings**

Based on the descriptive analysis, the following findings were obtained:

a. The study included 40 respondents.

b. The availability scores ranged from 22 to 55.

c. The overall mean availability score was 32.55.

d. The standard deviation was 7.62, indicating noticeable variation among respondents.

e. The median score was 30.

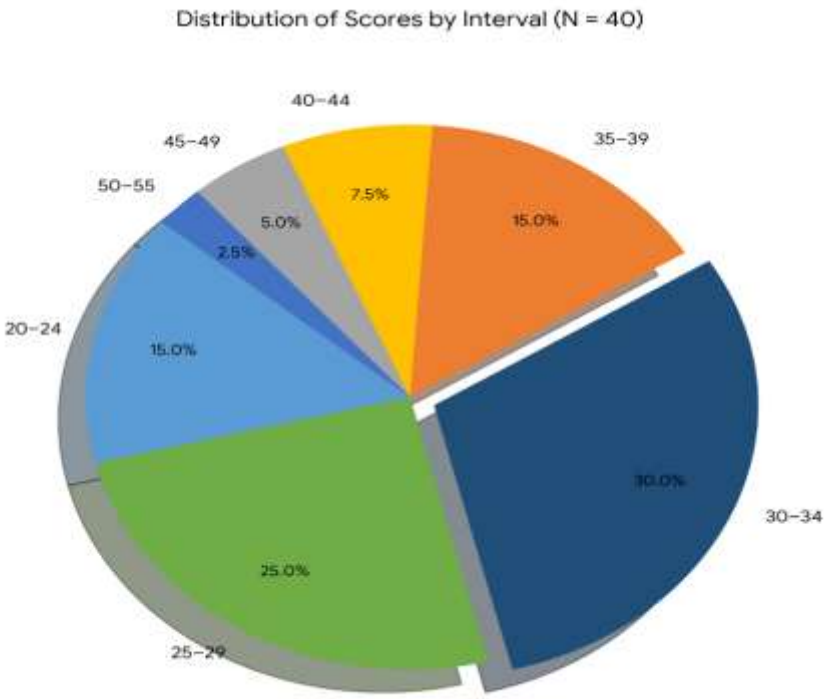
f. The highest individual score was 55, whereas the lowest was 22.

g. The largest group of respondents (30%) obtained scores between 30 and 34.

h. 55% of respondents obtained scores below 35.

i. Only 12.5%of respondents obtained scores of 40 or above.

j. Overall, the data suggest that the availability of virtual laboratory facilities was not consistently high among the respondents.




### 8.6 Statistical Technique Used

For this cross-sectional study, descriptive statistics were calculated as follows:

Percentage = $(Frequency)/NX100$

For the continuous total scores, the mean and standard deviation were calculated to describe central tendency and variability.

Limitations of the present report: The analysis is limited to the 20-item availability section and total scores for 40 respondents. The questionnaire used a three-point response scale, but the exact verbal labels for the response categories should be checked against the administered form before final submission. No separate accessibility item responses, expert-validation records, or item-level response matrix were available in the manuscript materials. The questionnaire's validity and reliability have not been established in this study; therefore, no Cronbach's alpha or content-validity index is reported. These should be addressed in a future instrument-validation study.

The descriptive pilot study found variation in the reported availability of virtual laboratory facilities among 40 intermediate science students. The mean availability score was 32.55 (SD = 7.62), with scores ranging from 22 to 55. These results describe the participating sample only and should not be generalized beyond it. The questionnaire used a three-point response scale; however, its validity and reliability have not been established in the present study. The dataset does not include separate accessibility scores. A larger study should collect item-level responses for both dimensions, undertake expert review and instrument validation, calculate Cronbach's alpha from item-level responses, and report the participating institution's name and location. The current findings should be treated as preliminary rather than as evidence of statistically significant differences.

The descriptive pilot study analysis revealed considerable variation in respondents' perceptions regarding the availability of virtual laboratory facilities. The mean availability score was 32.55 (SD = 7.62), with scores ranging from 22 to 55. The largest proportion of respondents (30%) obtained scores between 30 and 34, while 55% of respondents scored below 35. These findings indicate that virtual laboratory availability was not uniformly high among the respondents and that further strengthening of virtual laboratory infrastructure, access, and supporting facilities may be required.

## REFERENCE

1. Kachi, X. Y., Author, B. B., & Author, C. C. (2025). Accessibility and availability of virtual laboratories in secondary schools in Likuyani, Kenya. Journal Name, Volume(Issue), Page–Page.
2. Elmoazen, R., Saqr, M., &Tedre, M. (2021). Learning analytics in virtual laboratories: A systematic review. Journal/Conference Name, Volume(Issue), Page–Page. https://doi.org/xxxx
3. Peirson, N. F. (2025). Lived experiences of science education: A preliminary exploration of students' experience of truth in virtual and traditional science laboratories in further education. Research in Post-Compulsory Education, 30(1), 25–44. https://doi.org/10.1080/13596748.2025.2469010[cite: 1]
4. Ge, X., Wang, H., Wang, D., & Yang, B. (2025). AI-enhanced virtual laboratories improve learning outcomes and student engagement in food microbiology education. Scientific Reports, 15(1), Article Number. https://doi.org/xxxx
5. Widiarni, A. A., Author, B. B., & Author, C. C. (2026). Development of virtual reality learning medium using MilleaLab platform for physics education. Journal Name, Volume(Issue), Page–Page. https://doi.org/xxxx
6. Antón-Sancho, Á., Vergara, D., &Fernández-Arias, P. (2025). Application of virtual reality in university science education from a professors' perspective. Multimedia Tools and Applications, 84, 34121–34143.
7. Bajpai, M., & Kumar, A. (2015). Effect of virtual laboratory on students' conceptual achievement in physics. International Journal of Current Research, 7(2), 7619–7623.
8. 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
9. Dede, C. (2014). Digital tools for deeper learning. Harvard Education Press.
10. Holmes, W., Bialik, M., &Fadel, C. (2019). Artificial intelligence in education: Promises and implications for teaching and learning. Center for Curriculum Redesign.
11. Luckin, R., Holmes, W., Griffiths, M., &Forcier, L. B. (2016). Intelligence unleashed: An argument for AI in education. Pearson.
12. Makransky, G., Thisgaard, M. W., &Gadegaard, H. (2016). Virtual simulations as preparation for laboratory exercises: Assessing learning of key laboratory skills in microbiology. PLoS ONE, 11(6), e0155895. https://doi.org/10.1371/journal.pone.0155895

13. Means, B., Toyama, Y., Murphy, R., &Baki, M. (2013). The effectiveness of online and blended learning. Teachers College Record, 115(3), 1–47.
14. OECD. (2021). AI in education: Challenges and opportunities. OECD Publishing.
15. Rutten, N., van Joolingen, W. R., & van der Veen, J. T. (2012). The learning effects of computer simulations in science education. Computers & Education, 58(1), 136–153.
16. Smetana, L. K., & Bell, R. L. (2012). Computer simulations to support science instruction and learning. International Journal of Science Education, 34(9), 1337–1370.
17. Zhai, X., He, P., &Krajcik, J. (2021). Applying machine learning in science education research. Journal of Research in Science Teaching, 58(6), 779–800