Jurnal Inovasi Pendidikan IPA dan Etnosains (JIPIE)
Volume 1, Number 2, 2026 pp. 120-130
Open Access: https://ejournal.bbg.ac.id/jipie

IMPLEMENTATION OF AMRITA OLABS VIRTUAL PRACTICUM IN SCIENCE LEARNING ON STUDENTS' SCIENCE LITERACY: A SYSTEMATIC LITERATURE REVIEW

Rahma Nursalamah*[1] , Muhammad Minan Chusni[2]
[1,2]*Physics Education, UIN Sunan Gunung Djati Bandung, Jawa Barat, Indonesia*

* Corresponding Author: *nursalamahrahma@email.com*

ARTICLE INFO

Article history:
Received : 15 June 2026
Revised : 20 June 2026
Accepted : 21 Oct 2026
Available online : 31 Oct 2026

Kata Kunci:
Amrita OLabs, virtual laboratory, science education, scientific literacy, inquiry-based learning

Keywords:
Amrita OLabs, virtual laboratory, science education, scientific literacy, inquiry-based learning
indexing of the papers, are to be given.

ABSTRACT

Scientific literacy is an essential competency for students in the twenty-first century. However, the scientific literacy achievement of Indonesian students remains below the international average, highlighting the need for innovative science learning approaches. This study aimed to examine the implementation of Amrita OLabs in science education and its impact on students' scientific literacy. The study employed a Systematic Literature Review method using the Preferred Reporting Items for Systematic Reviews and Meta-Analyses framework. Relevant articles were identified from Scopus, Google Scholar, and Semantic Scholar databases and selected based on predetermined inclusion and exclusion criteria. Fourteen articles published between 2021 and 2025 were included in the review. The findings indicate that Amrita OLabs and similar virtual laboratories positively contribute to students' scientific literacy, particularly in conceptual understanding and scientific process skills. Interactive simulations and inquiry-based activities support students in understanding scientific concepts, conducting investigations, and interpreting evidence. Several studies also reported improvements in students' motivation, engagement, and independent learning. The effectiveness of implementation is influenced by instructional approaches, learning topics, students' initial literacy levels, and technological accessibility. Overall, Amrita OLabs has considerable potential to support science learning and improve students' scientific literacy when integrated with appropriate pedagogical strategies.

This is an open access article under the CC BY-NC license.
Copyright © 2026 by Author. Published by Universitas Bina Bangsa Getsempena

INTRODUCTION

Science literacy is a fundamental skill required of students in the 21st century. The Programme for International Student Assessment (PISA) defines science literacy as an

individual's ability to understand scientific questions, acquire new knowledge, explain phenomena scientifically, and draw evidence-based conclusions (OECD, 2018). This ability is not only important for aspiring scientists but also for every citizen to make responsible decisions regarding issues related to science and technology (Turiman et al., 2022). Consequently, the development of science literacy has become a primary objective in science education across various countries, including Indonesia.

In fact, Indonesian students' science literacy achievements remain below the global average. According to the 2022 PISA results, Indonesian students scored an average of 383 in science proficiency, far below the average of OECD countries (OECD, 2023). This situation places Indonesia in a concerning position among the 81 participating countries, with only about 34% of students achieving the basic proficiency level (Level 2) in scientific concept understanding (Bilad et al., 2024). Furthermore, PISA data indicates that students actively engaged in experimental and laboratory activities scored 25–40 points higher in science literacy compared to students who rarely participated in such activities (OECD, 2023). This underscores that the limited student involvement in science laboratory activities significantly contributes to the low levels of science literacy in Indonesia.

Science education should ideally be conducted through an inquiry-based approach that involves experiments and direct observation. However, the implementation of conventional laboratory work in schools often faces various challenges, including limited laboratory facilities, a shortage of materials and equipment, and safety risks associated with the use of hazardous substances (Widodo et al., 2021). This situation has been further exacerbated by the impact of the COVID-19 pandemic, which forced the shift to online learning, thereby severely limiting in-person laboratory activities (Alsaleh et al., 2022). Consequently, students have lost meaningful science learning experiences, which ultimately weakens the development of their science literacy.

In response to these challenges, virtual laboratories have emerged as a promising alternative in science education. A virtual laboratory is a technology-based learning environment that enables students to conduct interactive experiment simulations without being constrained by time or space (Widarti et al., 2022). Various studies indicate that the use of virtual laboratories can foster active student engagement, improve learning outcomes, facilitate self-directed learning, and motivate students through gamified interactions (Deriba et al., 2024). In fact, several studies state that the effectiveness of virtual laboratories in improving conceptual understanding and science process skills can match, or even surpass, that of conventional physical laboratories (Alhashem & Alfailakawi, 2023).

One virtual laboratory platform gaining attention in science education is Amrita OLabs (Online Labs). OLabs is an online laboratory platform developed by Amrita Vishwa Vidyapeetham, India, in collaboration with the Centre for Development of Advanced Computing (CDAC) in Mumbai (Amrita Vishwa Vidyapeetham, 2021). This platform provides hundreds of virtual experiments based on simulations, animations, and videos for science subjects—including Physics, Chemistry, and Biology—primarily intended for secondary school students. Amrita OLabs is equipped with interactive features that allow students to freely explore experimental variables, visualize processes that are difficult to observe directly, and receive immediate feedback on their observations (Azma et al., 2022). These advantages make OLabs a relevant choice for implementation in science education in the digital age. The use of virtual laboratories in science education has been shown to contribute to improvements in students' science literacy. Research conducted by Harianto et al. (2024) shows that the implementation of virtual laboratory media significantly improves students' scientific literacy and independent learning skills in science education. In line with this, Agushesa and Prastiwi (2024) found that the use of virtual laboratories has a positive effect on students' scientific literacy. A systematic review of various studies on virtual laboratories in science education also confirms that simulation-based laboratories—such as those implemented by OLabs—are the most frequently used and have a positive impact on improving learning outcomes, motivation, scientific process skills, and students' thinking skills (Lailiyah et al., 2024).

Although research on virtual laboratories in science education has been conducted extensively, studies specifically focusing on the implementation of Amrita OLabs and its impact on students' scientific literacy remain very limited, particularly within the context of Indonesian education. Most existing studies remain partial and have not been conducted systematically or comprehensively. The Systematic Literature Review (SLR) approach is considered appropriate to address this gap because it allows for the synthesis of empirical evidence from various studies in a transparent, structured, and replicable manner (Moher et al., 2020). Thus, this study aims to systematically examine the implementation of the Amrita OLabs virtual laboratory in science learning and its impact on students' science literacy based on Sinta- and Scopus-indexed journal articles published in the last five years.

RESEARCH METHODOLOGY

This study employed a Systematic Literature Review (SLR) method, adhering to the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses)

protocol, to identify, select, and analyze literature related to the implementation of Amrita OLabs in science education and its impact on students' science literacy.

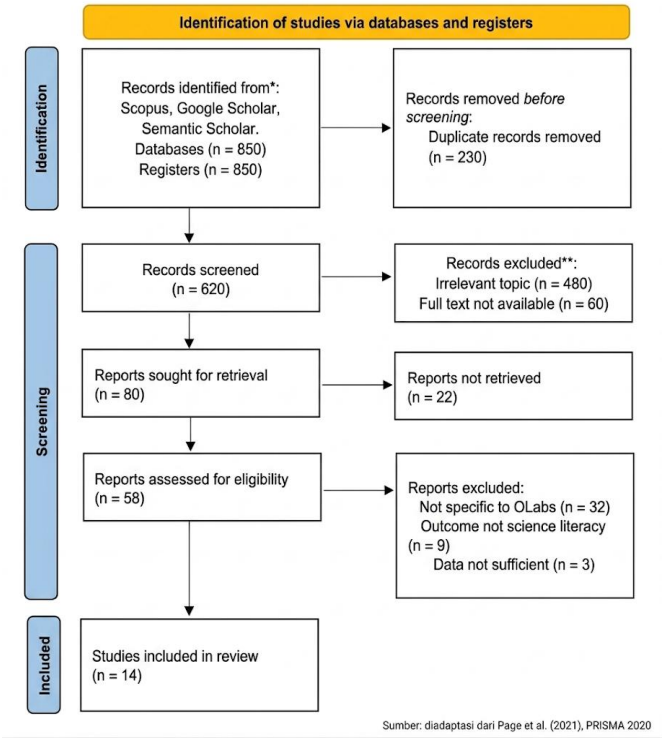


Figure 1. Article Selection Flow Based on the PRISMA Protocol

Selected articles met the following criteria: (1) published between 2021 and 2025, (2) discussed Amrita OLabs or similar virtual laboratories in science education, (3) examined science literacy, scientific process skills, or learning outcomes, and (4) were published in Sinta- or Scopus-indexed journals. Articles unavailable in full text, such as theses/dissertations, unindexed conference proceedings, or those irrelevant to the research topic were excluded from the analysis.

Article selection was conducted through the four PRISMA stages: identification, screening, eligibility assessment, and inclusion. The search was conducted in the Scopus, Google Scholar, and Semantic Scholar databases using the keywords "Amrita OLabs", "virtual laboratory", "virtual laboratory", and "science literacy". Of the 850 articles found, the selection process yielded 14 articles that met the criteria and were used as research data sources.

Data were analyzed using thematic analysis to identify patterns and key themes related to the implementation of Amrita OLabs and its impact on students' science literacy. The analysis results are presented in the form of summary tables and descriptive narratives to compare findings across studies.

This study is limited to articles indexed in Sinta and/or Scopus and focuses on the implementation of Amrita OLabs and similar virtual laboratories in science education related to science literacy.

RESULT AND DISCUSSION

Based on the systematic search and selection procedure following the PRISMA protocol described in the previous section, a total of **14 articles** were ultimately included for analysis. The selected articles originate from journals indexed in Sinta and Scopus, published between 2021 and 2025, and discuss the implementation of Amrita OLabs and similar simulation-based virtual laboratories in science education, as well as their impact on students' science literacy. A summary of the 14 selected articles, including the article title, author(s) and year of publication, journal index, subject matter, and key findings, is presented in Table 1.

Table 1. Summary of Selected Articles on the Implementation of Amrita OLabs and Virtual Laboratories in Science Education

No.	Article Title	Author(s) (Year)	Index	Subject Matter	Main Findings
1	Development of Amrita OLabs-Based Learning Media for Junior High School Students	Bitung et al. (2024)	Sinta 4	Integrated Science	The Amrita OLabs-based learning media was found to be feasible for implementation and helped students understand scientific concepts through visual and interactive learning experiences.
2	Development of E-LKPD Based on Guided Discovery Utilizing OLabs on Photosynthesis	Putri & Sari (2025)	Sinta 3	Biology	The OLabs-based E-LKPD was rated highly feasible (80%) for improving students' science process skills in the topic of photosynthesis.
3	Enhancing Students' Scientific Literacy Using Virtual Lab Activity with Inquiry-Based Learning	Putri et al. (2021)	Sinta 2	Physics	Students' scientific literacy scores increased from 68.27 to 81.25 (N-Gain = 0.441, moderate category) after participating in virtual laboratory-based learning activities.

4	The Effectiveness of Virtual Science Laboratories on Seventh-Grade Students' Science Process Skills	Hidayah et al. (2025)	Sinta 4	Science (Temperature and Heat)	The use of virtual science laboratories significantly improved students' science process skills compared to those in the control group.

As shown in Table 1, most of the reviewed studies (10 out of 14) reported positive effects of Amrita OLabs and similar virtual laboratories on students' scientific literacy, science process skills, and learning outcomes. The remaining studies focused on the development and validation of OLabs-based learning media or highlighted the relatively low initial level of students' scientific literacy. Figure 2 presents the distribution of the reviewed articles across the three dimensions of scientific literacy: content, process, and context.

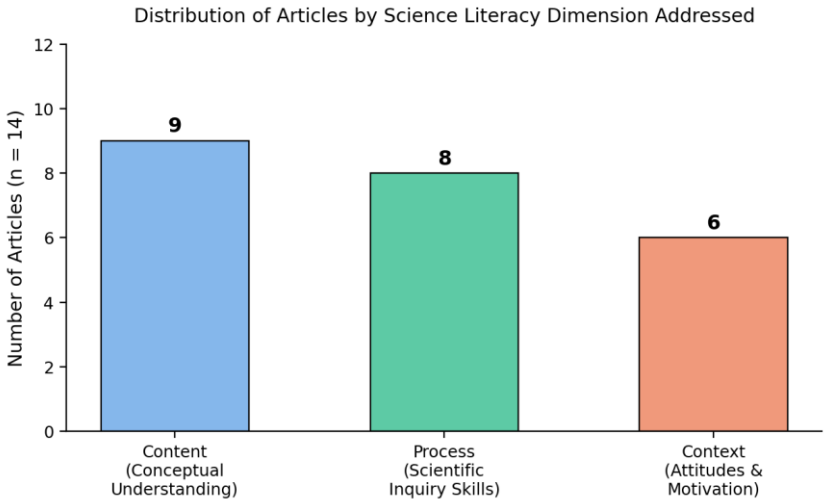


Figure 2. Distribution of Articles by Science Literacy Dimension Addressed

Figure 2 shows that the content dimension was addressed most frequently (9 articles), followed by the process (8 articles) and context (6 articles) dimensions. This indicates that research on Amrita OLabs has primarily focused on improving conceptual understanding, while its impact on attitudes and motivation has received less attention. The findings are discussed according to each dimension of scientific literacy.

The content dimension refers to students' understanding and application of scientific concepts. The reviewed studies indicate that Amrita OLabs and similar virtual laboratories positively improve this dimension. For example, Putri et al. (2021) reported an increase in science literacy scores from 68.27 to 81.25 (N-Gain = 0.441), while Harianto et al. (2024) found significant improvements in students' ability to explain scientific phenomena and interpret data. These improvements are attributed to the interactive and visual nature of virtual laboratories, which help students understand abstract scientific

concepts more effectively. However, the magnitude of the impact varies depending on the instructional approach, particularly when combined with guided inquiry or guided discovery models. This pattern is consistent with Setyowati et al. (2024), who developed an inquiry-based virtual laboratory to facilitate biology practicum activities for high school students and found that an inquiry-oriented design was considered feasible for helping students grasp concepts that are difficult to observe directly, reinforcing the importance of pairing virtual laboratories with structured inquiry strategies to strengthen conceptual understanding.

The process dimension includes skills such as formulating questions, conducting investigations, and interpreting evidence. Eight reviewed studies reported positive effects of virtual laboratories on these skills. Hidayah et al. (2025) found significant improvements in students' science process skills, while Putri and Sari (2025) demonstrated that OLabs-based E-LKPD effectively supports inquiry activities. The structured simulations, demonstrations, and self-assessment features of Amrita OLabs enable students to repeatedly practice scientific procedures. Studies also suggest that greater improvements occur when virtual laboratories are integrated with inquiry-based learning strategies. This result is corroborated by a recent quasi-experimental study by Purwati et al. (2025), who found that the use of a virtual science laboratory significantly improved seventh-grade students' science process skills on the topic of temperature and heat compared with conventional instruction, lending additional empirical support to the process-dimension findings of this review.

The context dimension relates to students' attitudes, motivation, and engagement in science learning. Six studies reported positive outcomes in this area. Harianto et al. (2024) found improvements in students' learning independence, while Bitung et al. (2024) reported increased interest and motivation toward science. These findings suggest that the interactive and self-paced characteristics of virtual laboratories can foster positive attitudes toward science. However, compared with the content and process dimensions, research on affective outcomes remains limited. A similar pattern was reported by Hermana et al. (2022), who found that implementing a virtual laboratory in junior high school science instruction simultaneously enhanced students' learning motivation and science process skills, suggesting that the affective and process dimensions of scientific literacy may develop in tandem rather than independently.

Several factors influence the effectiveness of Amrita OLabs. First, integrating OLabs with guided inquiry or guided discovery approaches produces stronger learning outcomes. Second, virtual laboratories are particularly effective for topics involving abstract or

difficult-to-observe phenomena, such as photosynthesis and evolution. Third, students with lower initial science literacy tend to show greater improvements. Finally, limited internet access and technological infrastructure remain challenges, especially in rural areas. These patterns align with broader international evidence synthesized by Van den Beemt et al. (2023), whose systematic review of virtual learning environments likewise found positive effects on multiple dimensions of scientific literacy, including knowledge acquisition, scientific reasoning, and attitudes toward science. While emphasizing that pedagogical design and implementation context strongly moderate these outcomes. This convergence between the present review and the broader international literature strengthens confidence in the conclusion that virtual laboratories such as Amrita OLabs can meaningfully support the development of students' scientific literacy.

Although Amrita OLabs has shown positive impacts, several challenges remain. The platform is not fully available in Indonesian, which may limit accessibility for some students. In addition, virtual laboratories cannot completely replace hands-on laboratory experiences. Therefore, Amrita OLabs should be implemented as a complement to physical laboratories within a blended learning approach. Teacher training and curriculum integration are also important to maximize its potential in improving students' scientific literacy.

CONCLUSIONS AND SUGGESTIONS

This systematic literature review examined the implementation of Amrita OLabs and similar virtual laboratories in science education and their impact on students' scientific literacy. Based on the analysis of 14 selected articles, the findings indicate that virtual laboratory implementation generally has a positive effect on the development of scientific literacy, particularly in the content and process dimensions. Amrita OLabs supports students' conceptual understanding through interactive visualizations and enhances scientific process skills by providing structured and repeatable inquiry experiences. In addition, several studies reported positive effects on students' motivation, interest, and learning independence, although research on these contextual aspects remains relatively limited. The findings also suggest that the effectiveness of Amrita OLabs is influenced by instructional approaches, learning topics, students' initial literacy levels, and technological accessibility.

BIBLIOGRAPHY

Achuthan, K., Nedungadi, P., Kolil, V. K., Diwakar, S., & Raman, R. (2020). Innovation adoption and diffusion of virtual laboratories. *International Journal of Online and Biomedical Engineering (iJOE)*, *16*(9), 4–25. https://doi.org/10.3991/ijoe.v16i09.11685

Achuthan, K., Raghavan, D., Shankar, B., Francis, S. P., & Kolil, V. K. (2021). Impact of remote experimentation, interactivity and platform effectiveness on laboratory learning outcomes. *International Journal of Educational Technology in Higher Education*, *18*(1), 1–24. https://doi.org/10.1186/s41239-021-00259-4

Agushesa, H. Y., & Prastiwi, M. S. (2024). Pengaruh penggunaan virtual laboratory terhadap kemampuan literasi saintifik siswa pada materi evolusi. *Berkala Ilmiah Pendidikan Biologi (BioEdu)*, *13*(2), 458–464. https://doi.org/10.26740/bioedu.v13n2.p458-464

AmritaCREATE. (2024). *OLabs: Online labs for school students*. Amrita Vishwa Vidyapeetham. https://www.olabs.edu.in

Aulia, F., Nurdiana, R., & Hidayat, T. (2024). Pengaruh penggunaan PhET simulation Hukum Newton sebagai media pembelajaran IPA berbasis ICT terhadap keterampilan proses sains siswa. *Eduproxima: Jurnal Ilmiah Pendidikan IPA*, *6*(1), 35–44. https://doi.org/10.29100/.v6i1.5707

Ayu, G. N., Putri, C. A., Riyanto, A. R., & Koto, I. (2025). The scientific literacy competence of students in Indonesia and Mexico based on PISA 2022: An international comparative study. *TOFEDU: The Future of Education Journal*, *4*(5), 1033–1038. https://doi.org/10.61445/tofedu.v4i5.525

Bobu, F. R., Ludji, D. G., & Rema, Y. O. L. (2024). Pelatihan pemanfaatan laboratorium virtual pada pembelajaran fisika bagi siswa SMA Negeri 1 Kefamenanu. *I-Com Indonesian Community Journal*, *4*(4), 2625–2632. https://doi.org/10.70609/icom.v4i4.5539

Budiman, I., Kaniawati, I., Permanasari, A., & Lukmana, I. (2021). Teachers' perspective on scientific literacy in science learning: Descriptive survey. *Jurnal Penelitian Pendidikan IPA*, *7*(Special Issue), 218–224. https://doi.org/10.29303/jppipa.v7iSpecialIssue.1123

Creswell, J. W., & Creswell, J. D. (2018). *Research design: Qualitative, quantitative, and mixed methods approaches* (5th ed.). SAGE Publications.

Darwis, R., & Hardiansyah, M. R. (2023). The effect of PhET virtual laboratory implementation on students' higher order thinking skills. *Jurnal Penelitian Pendidikan IPA*, *9*(4), 1922–1928. https://doi.org/10.29303/jppipa.v9i4.1979

Deriba, F. G., Saqr, M., & Tukiainen, M. (2024). Assessment of accessibility in virtual laboratories: A systematic review. *Frontiers in Education*, *9*, Article 1351711. https://doi.org/10.3389/feduc.2024.1351711

Fadda, D., Salis, C., & Vivanet, G. (2022). About the efficacy of virtual and remote laboratories in STEM education in secondary school: A second-order systematic review. *Educational, Cultural and Psychological Studies*, *2022*, 51–72. https://doi.org/10.7358/ecps-2022-026-fadd

Fuadi, H., Robbia, A. Z., Jamaluddin, J., & Jufri, A. W. (2020). Analisis faktor penyebab rendahnya kemampuan literasi sains peserta didik. *Jurnal Ilmiah Profesi Pendidikan*, *5*(2), 108–116. https://doi.org/10.29303/jipp.v5i2.122

Hamdani, H. (2025). Exploring publication trends, geographic contributions, and research collaborations in virtual labs for physics learning: A systematic literature review. *Jurnal Pendidikan Progresif*, *15*(1), 1–18. https://doi.org/10.23960/jpp.v15.i1.1679

Harianto, R., Umam, K., Nisa'Andawiyah, K., & Dhani, A. (2024). Efektivitas media virtual laboratory terhadap kemampuan literasi sains dan kemandirian belajar siswa dalam pembelajaran IPA. *Lensa (Lentera Sains): Jurnal Pendidikan IPA*, *14*(2), 95–103. https://doi.org/10.24929/lensa.v14i2.565

Hermana, A. D., Subekti, H., & Sabtiawan, W. B. (2022). Implementasi laboratorium virtual untuk meningkatkan motivasi belajar dan keterampilan proses sains siswa SMP. *Jurnal Penelitian Pendidikan IPA*, *8*(3), 1284–1291. https://doi.org/10.29303/jppipa.v8i3.1452

OECD. (2023). *PISA 2022 results (Volume I): The state of learning and equity in education*. OECD Publishing. https://doi.org/10.1787/53f23881-en

Page, M. J., McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., Shamseer, L., Tetzlaff, J. M., Akl, E. A., Brennan, S. E., Chou, R., Glanville, J., Grimshaw, J. M., Hróbjartsson, A., Lalu, M. M., Li, T., Loder, E. W., Mayo-Wilson, E., McDonald, S., … Moher, D. (2021). The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. *BMJ*, *372*, Article n71. https://doi.org/10.1136/bmj.n71

Pratama, R., Alamsyah, M., Siburian, M. F., Marhento, G., Jonathan, G. L., & Susanti, W. (2024). Analisis kemampuan literasi sains peserta didik pada mata pelajaran IPA. *Jurnal Pendidikan MIPA*, *14*(2), 576–581. https://doi.org/10.37630/jpm.v14i2.1619

Purwati, P., Darwis, R., & Natsir, N. A. (2025). Efektivitas laboratorium virtual IPA dalam meningkatkan keterampilan proses sains peserta didik kelas VII pada materi suhu dan kalor. *Jurnal Pendidikan MIPA*, *15*(1), 322–330. https://doi.org/10.37630/jpm.v15i1.2574

Putri, L. A., Permanasari, A., Winarno, N., & Ahmad, N. J. (2021). Enhancing students' scientific literacy using virtual lab activity with inquiry-based learning. *Journal of Science Learning*, *4*(2), 173–184. https://doi.org/10.17509/jsl.v4i2.27561

Reeves, S. M., & Crippen, K. J. (2021). Virtual laboratories in undergraduate science and engineering courses: A systematic review, 2009–2019. *Journal of Science Education and Technology*, *30*(1), 16–30. https://doi.org/10.1007/s10956-020-09866-0

Romli, S., Suhandi, A., Muslim, M., & Kaniawati, I. (2024). Research trends in the development of learning models oriented to increasing scientific literacy: A systematic literature review. *Indonesian Journal of Science and Mathematics Education*, *7*(1), 66–79. https://doi.org/10.24042/ijsme.v7i1.20517

Setyowati, A. P., Gunarhadi, G., & Musadad, A. A. (2024). Development of an inquiry-based virtual laboratory to facilitate biology practicum for high school students. *Multidisciplinary Science Journal*, *6*(12), 2024205. https://doi.org/10.31893/multiscience.2024205

Sugiyono. (2019). *Metode penelitian kuantitatif, kualitatif, dan R&D* (2nd ed.). Alfabeta.

Sulaiman, N. A. A., Hassan, S. A., Shaffril, H. A. M., & Hanapi, M. S. (2024). Integration of virtual labs in science education: A systematic literature review. *Jurnal Pendidikan Sains dan Matematik Malaysia*, *14*(1), 1–18. https://doi.org/10.37134/jpsmm.vol14.1.2024

Utami, L., & Adilla, R. (2022). Analisis keterampilan proses sains siswa menggunakan virtual laboratory Physics Education Technology (PhET) pada materi indikator asam basa. *Journal of Research and Education Chemistry*, *4*(1), 50–65. https://doi.org/10.25299/jrec.2022.vol4(1).9348

Van den Beemt, A., MacLeod, M., Van der Veen, J., Van de Ven, A., Van Baalen, S., Klaassen, R., & Boon, M. (2023). Virtual learning environment to improve scientific literacy: A systematic review. *Research in Science & Technological Education*, Advance online publication. https://doi.org/10.1080/02635143.2025.2547927

Wata, T. D., Yunus, S. R., & Ramlawati, R. (2022). Penggunaan laboratorium virtual dalam pembelajaran ilmu pengetahuan alam (IPA): Systematic literature review. *Jurnal Studi Guru dan Pembelajaran*, *5*(2), 112–121. https://doi.org/10.30605/jsgp.5.2.2022.1657

Yusmar, F., & Fadilah, R. E. (2023). Analisis rendahnya literasi sains peserta didik Indonesia: Hasil PISA dan faktor penyebab. *Lensa (Lentera Sains): Jurnal Pendidikan IPA*, *13*(1), 11–19. https://doi.org/10.24929/lensa.v13i1.238