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# Effectiveness of Virtual Laboratory-Based Interactive Learning Media Through a Differentiated Approach to Students' Scientific Literacy

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**Abstract:** This research aims to determine the extent to which the effectiveness of virtual laboratory-based interactive learning media through a differentiated approach can influence students' scientific literacy. The study was conducted on SMP Negeri 1 Tilango, Gorontalo district class VII students. This research uses a one-group pretest-post-test design. Based on the results of the T-Test, it was found that for the experimental class, the average ability of students to identify problems scientifically was 76.67%, the ability to explain scientific phenomena was 79.92%, and to draw conclusions based on scientific evidence was 70.49%. In the Replication class, the average ability of students to identify problems scientifically was 76.46%, the ability to explain scientific phenomena was 81.71%, and the ability to draw conclusions based on scientific evidence was 70.07%. An increase in students' scientific literacy was obtained using the N-Gain test, and the average results obtained in the experimental class were 0.85 (high) and the replication class 0.84 (high). This means that the students' scientific literacy skills in both the experimental and replication classes are in a good category, so it can be concluded that the virtual laboratory-based interactive learning media through a differentiated approach is effectively used as a learning media in science subjects, especially the material on substance and change.

**Keywords:** Effectiveness; Learning media; Scientific literacy; Virtual laboratory

## Introduction

Students are familiar with technology-related things in the process of acquiring knowledge, particularly in today's era. The learning process components consists of various interconnected components: curriculum, teachers, students, materials, methods, media, and evaluation (Fütterer et al., 2023; Irwan et al., 2024; Ramli et al., 2024). Learning media is any tool or resource that conveys messages and inspires students' thoughts, emotions, and motivations, fostering an effective learning process (Nasution et al., 2023; Hosna & Samsul, 2015; Clark & Mayer, 2023; Abubakar et al., 2023). One example of effective learning media is virtual laboratory-based interactive multimedia. Interactive media includes elements that allow users to interact actively with the subject they are studying, such as games, simulations, choices, and direct feedback (Brown, 2024; Jafnihirda et al., 2023; Garrand, 2023). It allows students to engage actively in the educational process through interactive exercises including asking questions, debate, and conduct experiments (Hilmi & Hasaniyah, 2023; Vale & Barbosa, 2023; May et al., 2023).

Interactive media that allows students to use applications freely and efficiently is a virtual laboratory (Darwis & Hardiansyah, 2021; Yusuf & Widyaningsih, 2020; Ali et al., 2022). Virtual laboratories are engaging

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and interactive simulation tools designed to illustrate and explain physical concepts or phenomena being studied (De Jong et al., 2013; Abdjul et al., 2019; Potkonjak et al., 2016; Daineko et al., 2017). According to Radhamani et al. (2021), virtual laboratories are one of the superior products of advances in information technology and laboratories, which are interactive places where simulation experiments can be carried out. The virtual laboratory consists of a simulation program domain that depends on it, experimental units called objects, which consist of data files, tools that operate on the objects, and reference books (Castro, 2024; Deniz et al., 2022).

Science learning with a virtual laboratory practicum with the PhET application can display interactive media in the form of images or animated movements designed to resemble a game. It has the potential to facilitate understanding of material concepts by allowing students to carry out experiments independently and in a way that best suits their needs (Darwis & Hardiansyah, 2023; Prasetya et al., 2022; Gunawan et al., 2023). A virtual laboratory is an interactive simulation media using fun applications that can attract students' interest in learning and explain physical concepts in the learning process outside or inside the classroom (Muslem & Mohammed, 2023; Apandi et al., 2023; Mensah, 2023).

One learning approach that can be used by implementing virtual laboratory-based interactive learning includes differentiation learning. Differentiated learning is learning created by teachers to meet the learning needs of students in the class, which includes learning readiness, interests, and learning profiles (Faiz et al., 2022). It can create effective learning and answer the diverse learning needs of students and their potential. So that students have the freedom to learn and their learning rights can be adequately fulfilled (Lagarusu et al., 2023).

Apart from learning media, choosing a learning approach is very important to assist students in addressing real-life challenges, such as a differentiated approach. Differentiated learning is one of the approaches used in managing the learning process, where students' characteristics and abilities are considered (Shaifudin, 2020). Differentiated learning is an essential method in education because each student is unique in learning and understanding the world around them. Differentiated learning is a responsive learning approach. It can accommodate differences in student learning styles, interests, previous knowledge, socialization needs, comfort zones, and encourages students to achieve learning goals together (Farinta & Mahmudi, 2024; Benjamin, 2002). Classroom learning quality can improve through appropriately differentiated learning, including literacy habituation activities (Pratama, 2022; Saptandari et al., 2022).

Virtual laboratory-based interactive learning media through a differentiation approach can help students analyze and addressing real-life challenges to prepare students for the workforce reflects the essence of scientific literacy, which involves applying knowledge to solve practical problems. Scientific literacy is a crucial goal in science education. The National Research Council in Ismail et al. (2016) stated that scientific literacy has become the primary objective of science education because it enables students to grasp concepts intellectually and develop scientific skills and attitudes that can be applied in real-world situations.

## Method

This research is classified as quantitative research with a quasi-experimental type with a pretest-posttest control group design. This research was conducted on SMP Negeri 1 Tilango, Gorontalo Regency class VII students in the academic year 2024/2025. The samples used in this research were class VIIa students as the experimental class and class VIIb as the replication class. Students in both classes are treated equally by applying virtual laboratory-based interactive learning media through a differentiated approach. The research flow chart uses the ADDIE (Analysis, Design, Development, Implementation, & Evaluation) development model in Figure 1.

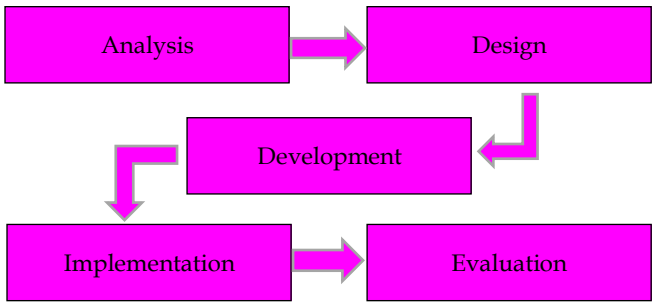


**Figure 1.** Flow chart of the ADDIE Model

This research was carried out in 7 meetings for the two classes. At the first meeting, students in the experimental and replication classes were given a pre-test, then continued with the same treatment, namely by implementing virtual laboratory-based interactive learning media through a differentiated approach to education. The research activity and implementation of virtual laboratory in the classroom in Figure 2 and Figure 3. After learning activities for the experimental class 3 times and the replication class 3 times, students in the two classes were given posttest questions to measure their' scientific literacy abilities.

The instrument employed in this research is a scientific literacy assessment with three indicators of scientific literacy according to PISA: identify problems scientifically, explain scientific phenomena clearly, and use scientific evidence. The statistical test used to determine the percentage of classical completeness of students' scientific literacy abilities in substance material and its changes is the independent sample t-test. The N-Gain test was utilized to measure the extent of improvement in students' scientific literacy skills after implementing virtual laboratory-based interactive learning media through a differentiated approach.

**Figure 2.** Research activity in the classroom

**Figure 3.** Implementation of virtual laboratory-based interactive learning

## Result and Discussion

Virtual laboratory-based interactive learning can enable students to participate actively in the learning process through interactive exercises, such as asking questions, debating, and conducting experiments. The effectiveness of interactive learning using virtual laboratories is evident in improving students' scientific literacy, particularly in their ability to identify scientific issues, explain scientific phenomena, and draw conclusions supported by scientific evidence. The students' scientific literacy consists of identifying problems scientifically (XX), describe scientific phenomena (XY) and conclude from scientific evidence (XZ). The percentage of students' scientific literacy in these three aspects can be seen in Figure 4.

Based on Figure 4, the experimental class, the average ability of students to identify problems scientifically was 76.67%, the ability to explain scientific phenomena was 79.92%, and to draw conclusions based on scientific evidence was 70.49%. In the Replication class, the average ability of students to identify problems scientifically was 76.46%, the ability to explain scientific phenomena was 81.71%, and the ability to draw conclusions based on scientific evidence was 70.07%. However, the literacy skills of experimental and replication class students in drawing conclusions based on scientific evidence are good (Sidiki et al., 2024; Janz, 2016; Oktaviani & Abdjul, 2024).

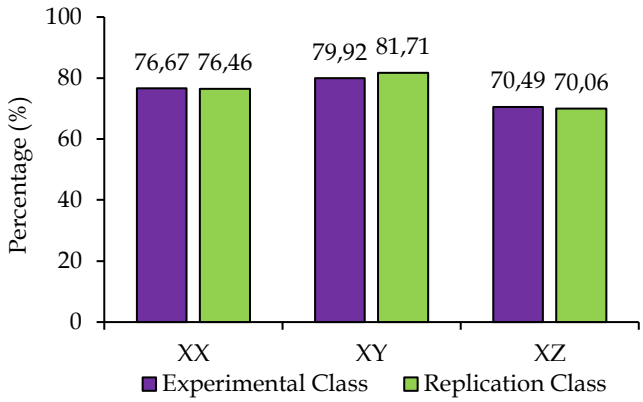


**Figure 4.** Percentage of Students' Scientific Literacy

The scientific literacy abilities of students in both experimental and replication classes have increased after implementing virtual laboratory-based interactive learning media through a differentiated approach (El-Sabagh, 2011; Parmar et al., 2024). This can be seen from the results of observations in Table 1.

**Table 1**. Results of N-Gain Test Analysis

| Category | Experimental class (%) | Replication class (%) |
|---|---|---|
| High | 91.30 | 87.50 |
| Medium | 8.70 | 12.50 |
| Low | 0.00 | 0.00 |

Based on Table 1, it can be seen that students in the experimental class who experienced an increase in scientific literacy were 91.30% in the high category, and 8.70% were in the medium category. If viewed per indicator, the improvement in students' scientific literacy was observed in their ability to scientifically identify problems, explain scientific phenomena, and draw conclusions based on scientific evidence in the experimental class reached an average of 0.85 in the high category. In the replication class, the ability to identify

problems scientifically, describe scientific phenomena and make inferences based on scientific evidence averaged 0.84 or was in the high category. The students' scientific literacy achievements in identifying problems scientifically and explaining scientific phenomena in the experimental and replication classes are in a good category.

Increasing students' scientific literacy due to the learning media used is one of the efforts to improve the quality of education, which aims to shift the use of conventional media towards the use of learning media that is in line with current technological and information developments in the era of revolution 4.0. A virtual laboratory is a software application designed to simulate experiments without physical execution. It enhances activities that are not feasible in real-life settings, making virtual laboratories an alternative medium for science practical to support practicums if impossible (Kusmawan, 2022; Ismail et al., 2016; Hendra et al., 2020; Rosli & Ishak, 2022). Learning implementation data is based on observer observations of class VII students (replication class) at meetings 1, 2, and 3, as shown in Figure 5.

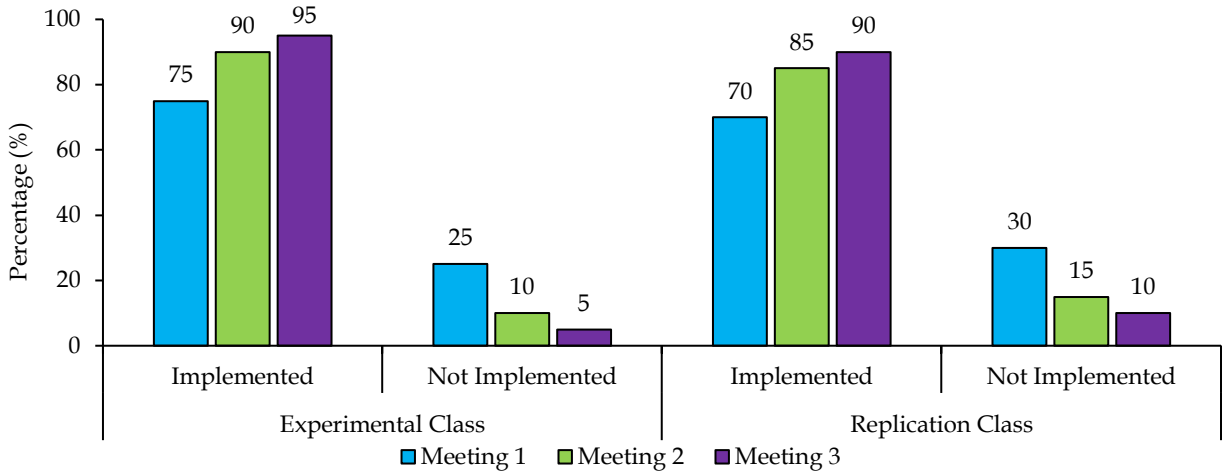


**Figure 5.** Percentage of Learning Implementation

Based on Figure 5 both in the experimental and replication classes, the teacher's implementation of learning by applying the learning media developed is, on average, in the very good category. For the experimental class, an average of 86.67% of learning implementation aspects were carried out very well, and 13.33% of aspects were not implemented. In the replication class, 81.67% of the learning implementation aspects were carried out well, and the teacher did not implement 18.33% of the learning aspects.

Student Responses in Class VII of SMP Negeri 1 Tilango are students' responses after implementing virtual laboratory-based interactive learning media using a differentiated approach in the experimental and replication classes in Table 2.

**Table 2.** Responses after implementing virtual laboratory-based interactive learning media

| Indicators | Experimental Class (%) | Replication Class (%) | Category |
|---|---|---|---|
| Feelings of Joy | 85.22 | 79.00 | Good |
| Involvement | 83.70 | 78.00 | Good |
| Interest | 81.52 | 88.20 | Good |
| Attention | 79.35 | 82.68 | Good |

Based on the data in Table 2, the average student response shows that feelings of happiness, involvement in learning, interest in the media, and attention to the teacher during the learning process are in a good category (Okono, 2023; El-Sabagh, 2011). Based on data on learning implementation and student responses to learning that applies virtual laboratory-based interactive learning media using a differentiated approach practically applied in learning, especially on the concept of substances and their changes.

## Conclusion

Virtual laboratory-based interactive learning can enable students to participate actively in the learning process through interactive exercises, such as asking questions, debating, and conducting experiments. Students in the experimental class who experienced an increase in scientific literacy were 91.30% in the high category, and 8.70% were in the medium category%. An increase in students' scientific literacy was obtained using the N-Gain test, and the average results obtained in the experimental class were 0.85 (high) and the replication class 0.84 (high). This means that the

students' scientific literacy skills in both the experimental and replication classes are in a good category.

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**Conflicts of Interest**
The authors declare no conflict of interest.

## References

Abdjul, T., Ntobuo, N. E., & Payu, C. (2019). Development of Virtual Laboratory-Based of Learning to Improve Physics Learning Outcomes of High School Students. *Jurnal Pendidikan Fisika Indonesia*, *15*(2), 97-106. https://doi.org/10.15294/jpfi.v15i2.12367

Abubakar, M., Alfian, W., & Rasyid, M. A. N. (2023). Students' Perceptions on the Instructional Media Used by Teacher in Teaching English. *Aisyah Journal of English Language Teaching (AIJELT)*, *2*(2), 43-63. https://doi.org/10.30604/aijelt.v2i2.1410

Ali, N., Ullah, S., & Khan, D. (2022). Interactive Laboratories for Science Education: A Subjective Study and Systematic Literature Review. *Multimodal Technologies and Interaction*, *6*(10), 85. https://doi.org/10.3390/mti6100085

Apandi, N. E. F. Z., Mokmin, N. A. M., & Rassy, R. P. (2023). Design and Development of Virtual Reality Science Laboratory on Science Education: An Analysis of Presences during Learning. *International Journal of Information and Education Technology*, *13*(11). https://doi.org/10.18178/ijiet.2023.13.11.1982

Benjamin, A. (2002). *Differentiated Instruction: A Guide for Middle and High School Teachers*. Eye on Education.

Brown, D. R. (2024). *Exploring Teachers' Perceptions of the Impact of Digital Game-Based Learning on Student Engagement, Motivation, and Learning Outcomes in K-12 Social Studies* (Master's Thesis). Florida Atlantic University). Retrieved from https://www.proquest.com

Castro M. Y. P. (2024). *Virtual Learning Objects for the Development of English Vocabulary in Students of Tenth Grade of Velasco Ibarra Educational Unit, Guamote Canton, Period 2023–2024* (Master's Thesis). Riobamba: Universidad Nacional de Chimborazo. Retrieved from http://dspace.unach.edu.ec/handle/51000/13888

Clark, R. C., & Mayer, R. E. (2023). *E-Learning and the Science of Instruction: Proven Guidelines for Consumers and Designers of Multimedia Learning*. John Wiley & Sons. Retrieved from http://books.google.com

Daineko, Y., Dmitriyev, V., & Ipalakova, M. (2017). Using Virtual Laboratories in Teaching Natural Sciences: An Example of Physics Courses in University. *Computer Applications in Engineering Education*, *25*(1), 39-47. https://doi.org/10.1002/cae.21777

Darwis, R., & Hardiansyah, M. R. (2021). Pengaruh Penerapan Laboratorium Virtual PhET Terhadap Motivasi Belajar IPA Siswa pada Materi Gerak Lurus. *ORBITA: Jurnal Pendidikan dan Ilmu Fisika*, *7*(2), 271-277. https://doi.org/10.31764/orbita.v7i2.5514

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

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

Deniz, S., Müller, U. C., Steiner, I., & Sergi, T. (2022). Online (Remote) Teaching for Laboratory-Based Courses Using "Digital Twins" of the Experiments. *Journal of Engineering for Gas Turbines and Power*, *144*(5), 051016. https://doi.org/10.1115/1.4053323

El-Sabagh, H. A. (2011). *The Impact of a Web-Based Virtual Lab on the Development of Students' Conceptual Understanding and Science Process Skills*. Retrieved from https://library.iated.org/view/ELSABAGH2010THE

Faiz, A., Pratama, A., & Kurniawaty, I. (2022). Pembelajaran Berdiferensiasi dalam Program Guru Penggerak pada Modul 2.1. *Jurnal Basicedu*, *6*(2), 2846-2853. https://doi.org/10.31004/basicedu.v6i2.2504

Farinta, N., & Mahmudi, A. (2024). Pengaruh Penerapan Pembelajaran Berdiferensiasi Terhadap Kemampuan Literasi Matematika Siswa Kelas VIII SMP pada Materi Bangun Ruang Sisi Datar. *Jurnal Pedagogi Matematika*, *10*(1), 48-56. https://doi.org/10.21831/jpm.v10i1.19756

Fütterer, T., Hoch, E., Lachner, A., Scheiter, K., & Stürmer, K. (2023). High-Quality Digital Distance Teaching During COVID-19 School Closures: Does Familiarity with Technology Matter?. *Computers & Education*, *199*, 104788. https://doi.org/10.1016/j.compedu.2023.104788

Garrand, T. (2023). *Writing for Interactive Media: Social Media, Websites, Applications, E-Learning, Games*. Retrieved from Taylor & Francis. http://books.google.com

Gunawan, A., Heliawati, L., & Permanasari, A. (2023). Effectiveness of Deep PhET Interactive Simulation Improving Understanding of The Concept of Material Change. *Journal of Science Education and Practice*, *7*(2), 92-102. https://doi.org/10.33751/jsep.v7i2.9213

Hendra, H. J., Lu'mu, L. M., & Suhaeb, S. (2020). Development of Remote Laboratory for Distance Learning Practicum Online and Real-Time Digital Electronics Subjects. *Journal of Educational Science and Technology*, *6*(1), 56-64. Retrieved from https://eprints.unm.ac.id/27532/

Hilmi, M., & Hasaniyah, N. (2023). *Penerapan Media Pembelajaran Digital dalam Pengajaran Bahasa Arab* (Undergraduate Thesis). UIN Malang. Retrieved from http://repository.uin-malang.ac.id/16718/

Hosna, R., & Samsul, S. (2015). *Melejitkan Pembelajaran dengan Prinsip-Prinsip Belajar*. Malang: Intelegensia Media.

Irwan, I., Arnadi, A., & Aslan, A. (2024). Developing Critical Thinking Skills of Primary School Students Through Independent Curriculum Learning. *Indonesian Journal of Education (INJOE)*, *4*(3), 788-803. Retrieved from https://injoe.org/index.php/INJOE/article/view/138

Ismail, I., Permanasari, A., & Setiawan, W. (2016). Efektivitas Virtual Lab Berbasis STEM dalam Meningkatkan Literasi Sains Siswa dengan Perbedaan Gender. *Jurnal Inovasi Pendidikan IPA*, *2*(2), 190-201. https://doi.org/10.21831/jipi.v2i2.8570

Jafnihirda, L., Suparmi, S., Ambiyar, A., Rizal, F., & Pratiwi, K. E. (2023). Efektivitas Perancangan Media Pembelajaran Interaktif E-Modul. *INNOVATIVE: Journal of Social Science Research*, *3*(1), 227-239. Retrieved from http://j-innovative.org/index.php/Innovative/article/view/2734

Lagarusu, A., Odja, A. H., & Payu, C. S. (2023). Pengaruh Penerapan Model Pembelajaran Problem Based Learning Melalui Pendekatan Berdiferensiasi Menggunakan Blended Learning Terhadap Hasil Belajar Siswa pada Konsep Fisika di SMA Negeri 6 Gorontalo Utara. *Jurnal Pendidikan Fisika Undiksha*, *13*(2), 317-324. Retrieved from https://ejournal.undiksha.ac.id/index.php/JJPF/article/view/60251

Janz, N. (2016). Bringing the Gold Standard Into the Classroom: Replication in University Teaching. *International Studies Perspectives*, *17*(4), 392-407. https://doi.org/10.1111/insp.12104

Kusmawan, U. (2022). A Virtual Lab as A Vehicle for Active Learning Through Distance Education. *International Journal on Research in STEM Education (IJRSE)*, *4*(2), 18-38. https://doi.org/10.31098/ijrse.v4i2.1188

May, D., Jahnke, I., & Moore, S. (2023). Online Laboratories and Virtual Experimentation in Higher Education from a Sociotechnical-Pedagogical Design Perspective. *Journal of Computing in Higher Education*, *35*(2), 203-222. https://doi.org/10.1007/s12528-023-09380-3

Muslem, M. T., & Mohammed, R. D. A. (2023). Designing A Virtual Electronic Program Based on Modeling and Simulation for Sixth Grade Physics Experiments. *Kurdish Studies*, *11*(2), 596-609. Retrieved from https://kurdishstudies.net/menu-script/index.php/KS/article/view/640

Mensah, M. K. (2023). *The Differential Effects of Physical and Virtual Laboratory Resources on Students' Performance in Electrochemistry A Comparative Study* (Doctoral Dissertation). University of Education, Winneba. Retrieved from http://ir.uew.edu.gh:8080/handle/123456789/2349

Nasution, W. N., Halimah, S., & Mahrisa, R. (2023). The Influence of Canva Application Learning Media and Learning Motivation on Students' Islamic Religious Education Learning Outcomes at Panca Budi Elementary School, Medan. *International Journal of Research and Review*, *10*(2), 772-783. https://doi.org/10.52403/ijrr.20230292

Okono, E. O. (2023). *Implications of Virtual Laboratory-Based Instruction on Students' Learning of Physics in Secondary Schools in Kenya*. Retrieved from http://41.89.195.24:8080/handle/123456789/2752

Oktaviani, I., & Abdjul, T. (2024). The Influence of Problem-Based Learning (PBL) Model on Student Learning Outcomes on the Concept of Measurement. *Jurnal Penelitian Pendidikan IPA*, *10*(8), 4498-4503. https://doi.org/10.29303/jppipa.v10i8.8059

Parmar, H., Siddhpura, M., & Siddhpura, A. (2024). Enhancing Student Engagement: Strategies for Effective Online Laboratory Instruction. *EDULEARN24 Proceedings*, 3654-3666. IATED. https://doi.org/10.21125/edulearn.2024.0945

Potkonjak, V., Gardner, M., Callaghan, V., Mattila, P., Guetl, C., Petrović, V. M., & Jovanović, 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

Pratama, A. (2022). Strategi Pembelajaran Berdiferensiasi Meningkatkan Kemampuan Literasi Membaca Pemahaman Siswa. *Jurnal Didaktika Pendidikan Dasar*, *6*(2), 605-626. https://doi.org/10.26811/didaktika.v6i2.545

Prasetya, F. M. A., Hakim, L., & Lefudin, L. (2022). Penerapan Laboratorium Virtual PhET Materi Elastisitas untuk Meningkatkan Hasil Belajar Siswa. *Jurnal Luminous: Riset Ilmiah Pendidikan Fisika*, *3*(1), 38-44. https://doi.org/10.31851/luminous.v3i1.7098

Radhamani, R., Kumar, D., Nizar, N., Achuthan, K., Nair, B., & Diwakar, S. (2021). What Virtual Laboratory Usage Tells Us About Laboratory Skill Education Pre-and Post-COVID-19: Focus on Usage, Behavior, Intention and Adoption. *Education and Information Technologies*, *26*(6), 7477-7495. https://doi.org/10.1007/s10639-021-10583-3

Ramli, H., Ibrahim, N., Prasetyaningrum, P. T., & Saedon, M. A. M. (2024). Graphic Design and Education: A Systematic Review on The Evolution, Diverse Aspects, Innovations in Teaching Methods, and Interconnected Changes in Design. *Journal of ICT in Education*, *11*(2), 42-54. https://doi.org/10.37134/jictie.vol11.2.4.2024

Rosli, R., & Ishak, N. A. (2022). Implementation of Virtual Laboratory in Learning Biology to Improves Students' Achievement, Science Process Skills and Self Efficacy. *International Journal of Education, Islamic Studies and Social Sciences Research*, *7*(1), 115-131. Retrieved from https://ijeisr.net

Saptandari, E. W., Febriani, A., & Kisriyani, A. (2022). Siap Sekolah dari Rumah: Stimulasi Aspek Sosial-Emosional pada Anak Usia Dini. *Jurnal Obsesi: Jurnal Pendidikan Anak Usia Dini*, *6*(5), 4417-4430. https://doi.org/10.31004/obsesi.v6i5.2002

Shaifudin, A. (2020). Pendekatan Sosio-Emosional dalam Pembelajaran. *EL WAHDAH*, *1*(1), 15-28. https://doi.org/10.35888/elwahdah.v1i1.4050

Sidiki, S. A. A., Abdjul, T., Lamangantjo, C. J., Buhungo, T. J., Yusuf, F. M., & Hermanto, I. M. (2024). The Implementation of PBL Model on Student Learning Outcomes in the Concept of Life Organizational Systems. *Jurnal Penelitian Pendidikan IPA*, *10*(8), 4486-4497. https://doi.org/10.29303/jppipa.v10i8.8100

Vale, I., & Barbosa, A. (2023). *Active Learning Strategies for an Effective Mathematics Teaching and Learning*. Retrieved from https://repositorium.uminho.pt/handle/1822/92319

Yusuf, I., & Widyaningsih, S. W. (2020). Implementing E-Learning-Based Virtual Laboratory Media to Students' Metacognitive Skills. *International Journal of Emerging Technologies in Learning*, *15*(5). https://doi.org/10.3991/ijet.v15i05.12029