Jurnal Pijar MIPA
https://jurnalfkip.unram.ac.id/index.php/JPM

ISSN 1907-1744 (Print)
ISSN 2460-1500 (Daring)

Implementation of Interactive Learning Media Based on Virtual Laboratory on Student Science Literacy Skills

Nurhalima Polihito, Tirtawaty Abdjul*, Nova Elysia Ntobuo, Muhammad Yusuf, Abdul Haris Odja, Nurhayati

Department of Science Education, Faculty of Mathematics and Natural Science, State University of Gorontalo, Gorontalo, Indonesia
*e-mail: tirtawaty@ung.ac.id

Received: May 25, 2025. Accepted: June 27, 2025. Published: June 30, 2025

Abstract: Virtual laboratories allow students to simulate experiments/practical work. This study aims to describe the application of interactive learning media based on virtual laboratories on students' scientific literacy skills in the material of substances and changes. This study uses a one-group pretest-posttest design, with three classes as research samples. The study was conducted in two schools, namely SMP Negeri 1 Tilango and SMP Negeri 1 Tilongkabila. The results of the study showed a significant increase in students' scientific literacy skills after students participated in learning using virtual laboratory media based on PhET Simulation. This media provides students with the opportunity to conduct virtual experiments, which has an impact on increasing their understanding of concepts and critical thinking skills. Based on the results of the analysis, the average posttest score of students was higher than the pretest score, which was 89.35 in the experimental class, 91.90 in replication class 1, and 88.64 in replication class 2. This fact shows that the use of virtual laboratories plays a positive role in improving student learning achievement. Thus, interactive learning media based on virtual laboratories can be used as an effective alternative to support science learning at the junior high school level.

Keywords: Interactive Learning Media; PhET Simulation; Science Literacy; Virtual Laboratory.

Introduction

Education is a conscious effort to pass on cultural values from one generation to the next. This process takes place in a learning environment designed to encourage active student involvement in developing spiritual potential, self-control, character, intelligence, moral values, and skills that are useful for personal and social life [1].

In learning, teachers play an important role as leaders. However, many teachers still do not have adequate competence, especially in terms of communication. Effective learning is needed in all subjects to create a conducive and interesting learning environment. Therefore, the ability of teachers to build good communication is very important so that the learning process runs as expected [2]. The role of teachers in science learning is still considered not optimal. There are still many teachers who only deliver material theoretically without providing an assessment of practice, so that students feel less interested. Ideally, science learning should combine theory and practice in a balanced way to develop scientific process skills and improve students' science literacy [3].

Science education at the secondary school level plays a very important role in preparing students to face increasingly complex global challenges. Science is not only about teaching existing concepts, but also about developing students' ability to think critically, observe, test, and draw conclusions based on valid evidence. In this context, scientific literacy is one of the basic skills that students must have. The scientific literacy skills of Indonesian students are still relatively low, as shown by various international studies such as PISA. This is one of the main challenges in learning Natural Sciences (IPA) in schools. In practice, science learning in many schools is still dominated by conventional methods that are centered on teachers and minimal practical activities. In fact, experimental and investigative activities are important elements in science learning to encourage understanding of concepts and application of knowledge in everyday life. Unfortunately, limited laboratory facilities, time, and resources often become obstacles in implementing practical work in the classroom.

In the 21st-century education era, one of the important skills that students need to have is scientific literacy. Scientific literacy includes the ability to understand scientific concepts and apply scientific processes in solving problems and drawing conclusions based on evidence, especially those related to natural phenomena [4]. Scientific literacy includes various important skills such as critical thinking, communication, creativity, and the ability to collaborate [5].

Scientific literacy includes the ability to understand science comprehensively and apply it in everyday life. In this modern era, scientific knowledge is an important element in driving progress. Scientific literacy is not only limited to mastering scientific concepts, but also includes the ability to apply scientific methods and knowledge effectively for the benefit of individuals, society, and the environment as a whole. This shows that scientific literacy has a broad impact, not only on personal life but also on society in general. Therefore, learning in schools should integrate the development of scientific literacy into its process [6].

Improving scientific literacy cannot be separated

How to quote:
N. Polihito, T. Abdjul, N. E. Ntobuo, M. Yusuf, A. H. Odja, and N. Nurhayati, "Implementation of Interactive Learning Media Based on Virtual Laboratory on Student Science Literacy Skills", *J. Pijar.MIPA*, vol. 20, no. 4, pp. 681–686, Jun. 2025.
https://doi.org/10.29303/jpm.v20i4.9138

from the way science is taught. In the practice of science learning, students often find it difficult to understand abstract or complex concepts only through verbal explanations or theories given by teachers. One approach that can help overcome this obstacle is to utilize interactive learning media based on virtual laboratories.

Interactive media plays a role in helping teachers organize the learning process more systematically and reduce dependence on delivering material in the form of long texts, because it supports the process of sharing information. The presence of collaborative features in interactive media also allows adjustments to various student learning styles. If students' learning needs are not met, this can cause a decrease in their level of attention and motivation. Therefore, the use of interactive learning media can increase student interest and encourage their enthusiasm in following the learning process.[7].

Interactive learning media based on virtual laboratories provide students with direct experience to conduct experiments, test hypotheses, and explore scientific phenomena in a more engaging and interactive format. For example, the use of PhET Simulation, an interactive simulation that can be accessed for free via the PhET website (Physics Education Technology) and utilized in classroom learning activities [8].

This interactive learning media, based on virtual laboratories, is very useful in facilitating students' understanding of concepts that are not easily observed directly, such as changes in substances at the molecular level. Through simulations, students can see how a substance changes form or how a chemical reaction occurs under conditions that can be adjusted according to the needs of the experiment. This provides an opportunity for students to learn in a more active and contextual way, which in turn can improve their scientific literacy skills, especially in terms of connecting theory with practical applications.

In addition, virtual laboratory-based learning allows students to develop critical thinking skills and problem-solving, which is an integral part of scientific literacy. Through virtual experiments, students not only learn about the theories taught but also learn how to explore a scientific problem, collect data, analyze results, and draw conclusions based on the evidence obtained. This process teaches students to think analytically and systematically, which are important skills in scientific literacy. In this case, students' ability to understand and apply scientific concepts actively in virtual experiments is an important step in improving their competence in science.

However, although virtual laboratories offer many advantages, the challenges in their implementation cannot be ignored. The use of this virtual media requires adequate technological skills, both from the teacher and the students. Therefore, to ensure that the implementation of virtual laboratories can run effectively, training and development of technological skills among teachers are needed, as well as adequate facility support. Furthermore, this study aims to see how the implementation of interactive learning media based on virtual laboratories can affect students' scientific literacy skills, especially in materials that require practical experiments, such as materials on substances and their changes.

Research methods

This research uses the *Quacy* Experiment method, which is a type of research that aims to identify the effect of a treatment on a subject, but does not fully involve randomization in the formation of the experimental group. The research design applied is a one-group pretest-posttest Design. The research was conducted on grade VII students at SMP Negeri 1 Tilongkabila and SMP Negeri 1 Tilango in the 2024/2025 academic year. The number of research subjects was 23 students in the experimental class (grade VII.1 SMP Negeri 1 Tilango), 25 students in replication class 1 (grade VII.1 SMP Negeri 1 Tilango), and 22 students in SMP Negeri 1 Tilongkabila as replication class 2. The sampling technique used was cluster sampling, namely sampling from several different schools. The instrument used in this study was a descriptive test consisting of 10 questions, which was given before learning (pre-test) and after learning (post-test). The instrument used in this study has gone through a validation process by two validators and was declared to meet the criteria of being very valid and reliable. Data analysis was carried out by applying several statistical techniques, one of which was the normality test used to determine whether the pretest and posttest data had a normal distribution. According to [9], the normality test is a procedure carried out to determine whether the data distribution follows a normal distribution pattern. There are various techniques that can be applied in normality testing, and each method can produce different decisions. After conducting the normality test, a hypothesis test and an n-gain test were carried out. Hypothesis testing is a procedure in statistics used to assess the validity of an assumption or statement that is still tentative and has not been empirically proven [10].

Results and Discussion

The learning process is designed so that students can achieve scientific literacy. Scientific literacy itself is a benchmark used to assess the extent to which someone can understand, apply, and examine scientific information. Students' scientific literacy abilities are identified through tests or questions that are compiled based on relevant indicators. In this study, the measurement of students' scientific literacy was carried out referring to certain scientific literacy indicators. According to PISA, there are 3 indicators of scientific literacy according to PISA, namely 1). Identifying problems scientifically, 2) Explaining scientific phenomena clearly, 3) Using scientific evidence. After that, the average percentage of students' scientific literacy abilities in each sample class was calculated [11].

Based on the data in Figure 1 regarding the Percentage of Science Literacy Achievement, it can be seen that each class experienced an increase in the percentage of each science literacy indicator. Replication class 1 showed the highest percentage compared to the other classes. In*Pre-test*, this class recorded an achievement of 65% for indicator 1, 68% for indicator 2, and 56% for indicator 3. Of the three indicators, indicator 2 had the highest achievement. After treatment, the percentage *post-test* increased significantly: indicators 1 and 3 reached 92%, while indicator 2 rose to 97%.

Percentage of scientific literacy achievement in the experimental class, indicator 1 records the percentage, pre-test highest, namely 66%, followed by indicator 2 with 64% and indicator 3 with 42%. The results post-test also showed an increase, each to 92% (indicator 1), 95% (indicator 2), and 89% (indicator 3). Meanwhile, in replication class 2, indicator 2 recorded a value of pre-test highest, namely 67%, followed by indicator 1 at 61% and indicator 3 at 58%. The results post-test show an increase, with indicator 1 reaching 93%, indicator 2 at 89%, and indicator 3 at 88%.

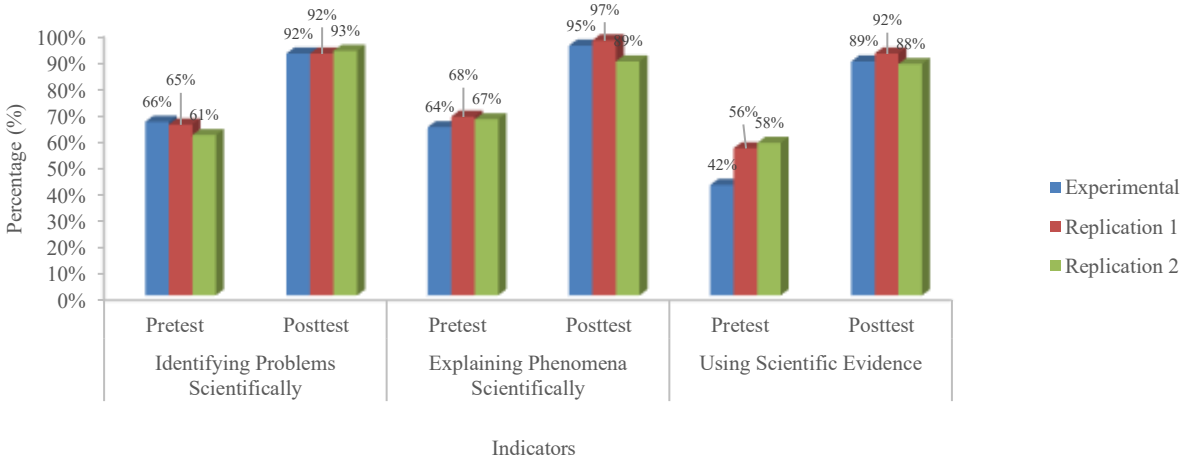

Figure 1. Percentage of Students' Science Literacy Achievement

Based on the percentage of scientific literacy achievement obtained from the average post-test score in the experimental class, replication 1, and replication 2, it can be concluded that the indicator explaining scientific phenomena (indicator 2) has a higher achievement compared to the indicator analyzing problems scientifically and the indicator proving scientifically. This shows that students find it easier to understand and explain phenomena that are clearly visible through simulations or virtual experiments, compared to activities that require in-depth analysis and application of more complex concepts. Virtual laboratories are effective in improving students' scientific literacy, especially in the ability to explain scientific phenomena [12].

The scientific literacy indicator "explaining scientific phenomena scientifically" showed the highest percentage of achievement compared to other indicators. In the study, the posttest results on this indicator reached 96% in the very good category, while the indicator "interpreting scientific data and evidence" only reached 71% in the good category. This finding indicates that students tend to find it easier to understand and communicate scientific phenomena compared to their ability to interpret scientific data and evidence [13].

The researcher used the average method for each sample class in analyzing the distribution of quantitative data and observing the increase in students' science literacy after using interactive learning media based on virtual laboratories. The values for *Pre-test* and *post-test* from the experimental class, replication 1, and replication 2 were calculated using the Excel application, as shown in Figure 2.

Based on the percentage of students' scientific literacy achievements obtained from the average value *post-test* in the experimental class, replication 1 and replication 2 showed that indicator 2 obtained a higher percentage of scientific literacy compared to indicators 1 and 3. This is due to the tendency of students who find it easier to understand and explain scientific phenomena that are clearly visible through simulations or virtual experiments. In contrast, skills such as identifying problems or using scientific evidence require a more complex understanding and deeper application of concepts. This finding is in line with the results of research [10], which states that the use of PhET simulations in virtual experiments is able to present visualizations of abstract concepts, thereby helping students understand the material. Similar support is also shown in research by [14], which found that the use of virtual laboratory media is effective in improving students' understanding of the concept of sound waves. This success occurs because virtual experiments can present visualizations of abstract concepts in a concrete way, helping students strengthen their understanding and accelerate the process of internalizing the material being studied.

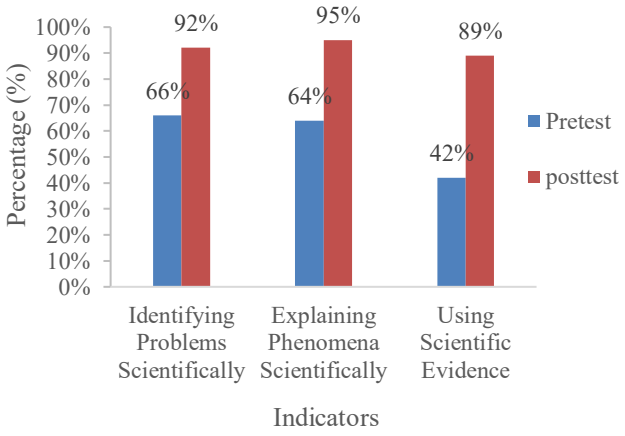

Figure 2. Average Calculation Results of the Pretest and Posttest

The success of this study was influenced by various factors, including the implementation of active learning strategies such as group discussions, problem-based learning models, and the use of interactive media based on virtual laboratories through PhET simulations. These media not only attract students' interest but are also closely related to real-life situations, thus increasing the relevance of learning. Students' active participation in learning activities that emphasize problem solving also contributes significantly to improving their critical and high-level thinking skills.

Based on the analysis results, the average value post-

test in all sample classes is higher than the value pre-test, which indicates an increase in students' scientific literacy skills in the topic of substances and their changes after the implementation of interactive learning media based on virtual laboratories. This finding is in line with research [15], which examined the effectiveness of PhET simulations as laboratory learning media in improving understanding of science concepts. The results of the study showed that the use of PhET simulations can strengthen students' understanding of complex science concepts, especially material related to abstract physical phenomena. Overall, the results of this study confirm that virtual laboratories based on PhET simulations are an effective learning alternative in improving students' scientific understanding and literacy.

Data Normality Test

This study uses the Kolmogorov-Smirnov test as a method to test data normality, with the aim of knowing whether the data obtained follows a normal distribution or not. The results of the statistical analysis related to the normality test are presented in Table 1.

Table 1. Normality Test Results

Class	Fi	K	Status
Experiment	0.47	0.28	Normally Distributed
Replication 1	0.48	0.26	Normally Distributed
Replication 2	0.47	0.28	Normally Distributed

Based on the table above, the results of the normality test show that each sample class has a Fi value greater than or equal to K at a significance level of $\alpha = 0.05$. Thus, it can be concluded that the data from the three classes are normally distributed. This normal distribution is an important aspect because it is one of the main requirements for conducting valid statistical analysis, as well as being the basis for interpreting research results related to the effectiveness of the learning media used. This normal distribution is an important requirement in valid statistical analysis and provides a strong foundation for interpreting research results, especially related to the effectiveness of the learning media used. The normality test is an important stage in statistical analysis, because many parametric methods rely on the assumption of a normal distribution. If the data is not normally distributed, the results of the analysis can be biased or less accurate, so understanding the normality test is very important before proceeding to the next stage of analysis [16-18].

Hypothesis Testing

Hypothesis testing in this study was carried out using a parametric statistical approach using a paired t-test because the analysis is intended to compare the results of students' scientific literacy before and after the treatment is given. The use paired t-test aims to determine whether there is a significant difference in students' scientific literacy abilities after participating in learning with interactive media based on virtual laboratories on the material of substances and their changes.

Testing was conducted on each class, namely the experimental class, replication 1, and replication 2, with the aim of assessing the consistency of the impact of implementing learning media in each class that received similar treatment. The results of the hypothesis test for the three classes are presented in Table 3.

Table 2. Hypothesis Testing Results

Class	t-count	t-table	Status
Experiment	11.27	2.07	H_a accepted
Replication 1	15.64	2.06	H_a accepted
Replication 2	17.71	2.08	H_a accepted

Based on the analysis results presented in Table 2, it is known that the value t-count is greater than or equal to t-table at a significance level of $\alpha = 0.05$ for the experimental class, replication 1, and replication 2. If the value t-count ≥ t-table at a certain level of significance, then $H_{0\ is}$ rejected and $H_{a\ is}$ accepted [19-20]. Thus, in this study, the null hypothesis (H_0) is rejected and the alternative hypothesis (H_a) is accepted. This finding shows that the application of interactive learning media based on virtual laboratories on the material of Substances and Their Changes has a significant impact on students' scientific literacy in all three classes. The effectiveness of this media is shown through a significant increase in values when post-test compared to the pre-test.

Uji N-Gain

This study analyzes the n-gain value using the approach-course average normalized gain, which calculates the average increase in students' science literacy results that have been normalized based on each class. The results of the n-gain analyzis for each class are presented in Table 3.

Table 3. N-Gain Test Results

Class	N-Gain	Criteria
Experiment	0.76	High
Replication 1	0.83	High
Replication 2	0.75	High

Referring to the data in Table 3, regarding the N-Gain Test Results, it can be seen that the experimental class, replication 1, and replication 2 experienced an increase in scientific literacy skills that were in the high category. This finding indicates that the application of interactive learning media based on virtual laboratories plays a positive role in improving students' scientific literacy on the material of substances and their changes.

Conclusion

This study shows that interactive learning media based on virtual laboratories significantly improve students' scientific literacy on the material of substances and their changes at SMP Negeri 1 Tilango and SMP Negeri 1 Tilongkabila. The results of the hypothesis test show $t_{count} \geq t_{table}$ at a significance level of 0.05 in all classes, meaning Ha is accepted. The N-gain values obtained were also high: 0.76 (experimental class), 0.83 (replication 1), and 0.75 (replication 2). This media has proven effective in increasing student understanding and active involvement during learning, so it is recommended for use in science learning more widely.

Author Contributions

Nurhalima Polihito: Conceptualization, Drafting of Original Paper, Methodology; Tirtawaty Abdjul: Curation, Writing-original drafting; Nova Elysia Ntobuo: Methodology; Muhammad Yusuf: Writing–review and editing; Abdul Haris Odja: Formal Analysis, Methodology; Nurhayati: Validation.

Acknowledgement

The researcher would like to thank all parties who have helped in this research. To the principal, teachers and students at SMP Negeri 1 Tilango and SMP Negeri 1 Tilongkabila, for their support in completing this research.

Reference

[1] A. Rahman, S. A. Munandar, A. Fitriani, Y. Karlina, and Yumriani, "Pengertian Pendidikan, Ilmu Pendidikan dan Unsur-Unsur Pendidikan," *Al Urwatul Wutsqa: Kajian Pendidikan Islam*, vol. 2, no. 1, pp. 1–8, 2022.

[2] N. Nurkhairina and R. Assingkily, "Analisis Model Komunikasi Pembelajaran Kelas 1 Tema 1 Diriku dan Kelas IV Tema 1 Indahnya Kebersamaan," *EDU SOCIETY: Jurnal Pendidikan, Ilmu Sosial dan Pengabdian kepada Masyarakat*, vol. 1, no. 1, 2023. [Online]. Available: https://doi.org/10.56832/edu.v1i1.31

[3] R. Fauzi, A. Anugrahana, and P. B. Yan Ariyanti, "Penerapan Model Pembelajaran Problem Based Learning (PBL) untuk Meningkatkan Hasil Belajar IPA tentang Pemahaman Sifat-Sifat Cahaya pada Kelas IV SD Negeri Plaosan 1," *Jurnal Pendidikan Tambusai*, vol. 7, no. 1, 2023. [Online]. Available: https://doi.org/10.31004/jptam.v7i1.5605

[4] S. Arlis *et al*., "Literasi Sains Untuk Membangun Sikap Ilmiah Siswa Sekolah Dasar," *Jurnal Cakrawala Pendas*, vol. 6, no. 1, pp. 1–14, 2020. [Online]. Available: https://doi.org/10.31949/jcp.v6i1.1565

[5] L. Banila, H. Lestari, and R. Siskandar, "Application of Blended Learning with a STEM Approach to Improve Students' Science Literacy Ability during the Covid-19 Pandemic," *Journal of Biology Learning*, vol. 3, no. 1, p. 25, 2021.

[6] Zuryanty, Y. Hamimah, Y. Helsa, and A. K. Kenedi, "Pelatihan Pengembangan Bahan Ajar Literasi Sains Berbasis Teknologi untuk Guru Sekolah Dasar," *Jurnal Cakrawala Ilmiah*, vol. 1, no. 8, 2022. [Online]. Available: https://doi.org/10.53625/jcijurnalcakrawalailmiah.v1i8.2025

[7] S. Asela, U. H. Salsabila, N. H. P. Lestari, A. Sihati, and A. R. Pertiwi, "Peran Media Interaktif dalam Pembelajaran PAI Bagi Gaya Belajar Siswa Visual," *Jurnal Inovasi Penelitian*, vol. 1, no. 3, 2020. [Online]. Available: https://doi.org/10.47492/jip.v1i7.242

[8] E. M. Ramadani and Nana, "Penerapan Problem Based Learning Berbantuan Virtual Lab Phet pada Pembelajaran Fisika Guna Meningkatkan Pemahaman Konsep Siswa SMA: Literature Review," *Jurnal Pendidikan Fisika Tadulako Online (JPFT)*, vol. 8, no. 1, 2020.

[9] I. Sintia, M. D. Pasarella, and D. A. Nohe, "Perbandingan Tingkat Konsistensi Uji Distribusi Normalitas Pada Kasus Tingkat Pengangguran di Jawa," *Prosiding Seminar Nasional Matematika, Statistika, dan Aplikasinya*, vol. 2, no. 2, pp. 322–333, 2022.

[10] H. D. Siregar, M. Wassalwa, K. Janani, and I. S. Harahap, "Analisis Uji Hipotesis Penelitian Perbandingan Menggunakan Statistik Parametrika," *Al Itihadu Jurnal Pendidikan*, vol. 1, no. 1, p. 3, 2022. [Online]. Available: https://jurnal.asrypersadaquality.com/index.php/alittihadu/article/view/44

[11] L. Chandra, "Upaya Meningkatkan Kemampuan Literasi Sains dan Psikomotorik Peserta Didik Melalui Scientific Hybrid Learning dengan Aplikasi Virtual Lab," *EDUTECH: Jurnal Inovasi Pendidikan Berbantuan Teknologi*, vol. 1, no. 3, pp. 297–301, 2021. [Online]. Available: https://doi.org/10.51878/edutech.v1i3.740

[12] T. Abdjul and A. H. Odja, "Effectiveness of Virtual Laboratory-Based Interactive Learning Media Through a Differentiated Approach to Students' Scientific Literacy," *JPPIPA*, vol. 10, no. 11, 2024. [Online]. Available: https://doi.org/10.29303/jppipa.v10i11.9253

[13] W. Istiqomah, A. Purwanto, and R. Medriati, "The Influence of Problem-Based Learning on Science Literacy Ability of Physics Students," *Jurnal Pendidikan Matematika dan IPA*, vol. 14, no. 2, pp. 188–199, 2023.

[14] W. P. Medica, I. Suyana, and D. E. Tarigan, "Penggunaan media virtual laboratory dalam pembelajaran untuk meningkatkan pengetahuan konsep gelombang bunyi," *WaPFi (Wahana Pendidikan Fisika)*, vol. 7, no. 1, pp. 83–92, 2021. [Online]. Available: https://doi.org/10.17509/wapfi.v7i1.36964

[15] N. Inayah and M. Masruroh, "PhET Simulation Effectiveness as Laboratory Practices Learning Media to Improve Students' Concept Understanding," *Prisma Sains: Jurnal Pengkajian Ilmu dan Pembelajaran Matematika dan IPA IKIP Mataram*, vol. 9, no. 2, p. 152, 2021. [Online]. Available: https://doi.org/10.33394/j-ps.v9i2.2923

[16] N. Maesaroh and P. Y. Sutikno, "Effectiveness of the PhET Simulation Assisted by Songs to Improve Students' Critical Thinking Skills in Electrical Circuits," *Jurnal Pijar Mipa*, vol. 20, no. 2, pp. 356–364, 2025. [Online]. Available: https://doi.org/10.29303/jpm.v20i2.8729

[17] M. I. M. Hidayat and H. Subekti, "Promoting science process skills and learning outcomes through cybergogy approaches with PhET media for Junior High School Students," *Jurnal Pijar Mipa*, vol. 17, no. 4, pp. 499–506, 2022. [Online]. Available: https://doi.org/10.29303/jpm.v17i4.3623

[18] I. Muhammad, M. W. Afgani, and I. A. Al Haqqi, "Teknik Analisis Data Uji Normalitas," *J-CEKI: Jurnal Cendekia Ilmiah*, vol. 4, no. 2, 2025.

[19] V. M. Anisa and D. Astriani, "Implementation of PhET simulation with discovery learning model to improve understanding of dynamic electricity concepts," *Jurnal Pijar Mipa*, vol. 17, no. 3, pp. 292–301, 2022. [Online].

Available: https://doi.org/10.29303/jpm.v17i3.3438
[20] F. A. Suwele, I. N. Arifin, G. Abdullah, A. Haris, and R. M. Arif, "Pengaruh Model Project Based Learning Berbantuan Media Sederhana Terhadap Hasil Belajar IPA Siswa di Kelas V SDN 3 Kabila Bone," *Jurnal Pendidikan*, vol. 7, no. 3, pp. 1131–1141, 2024.