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Article

Improving Fourth-Grade Science Learning on Force through Demonstration Method: A Classroom Action Research

Noor Hidayah[1*], Asep Irvan Irvani[2]

[1] Universitas Terbuka, noorhdyah2002@gmail.com
[2] Universitas Garut, irvan.irvani@uniga.ac.id
* Correspondence: noorhdyah2002@gmail.co

Abstract: This study aimed to improve fourth-grade students' understanding of the concept of force and their learning outcomes in science through the application of the demonstration method. Using the Classroom Action Research (CAR) approach with the Kemmis and McTaggart model, the research was conducted in two cycles, each consisting of planning, implementation, observation, and reflection stages. The participants were 26 fourth-grade students at SD Negeri 002 Sungai Pinang. Data were collected using formative tests to measure students' achievement and observation sheets to evaluate their engagement during learning. The Minimum Learning Completion Standard (SKBM) was set at 72. Results indicated a significant improvement in student achievement, with the percentage of students meeting the SKBM increasing from 58% in cycle I to 85% in cycle II. This improvement was attributed to the more participatory and interactive strategies implemented in the second cycle, including active student involvement in demonstrations, simple experiments, and group discussions. The findings suggest that demonstration-based teaching not only enhances conceptual understanding but also fosters student motivation and engagement. Therefore, this method is recommended as an effective alternative for improving the quality of science education in elementary schools and can be further integrated with other interactive approaches to optimize learning outcomes.

Keywords: Classroom Action Research; Demonstration Method; Elementary Education; Force Concept; Science Learning; Student Engagement; Student Learning Outcomes

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1. Introduction

Education is essentially a planned process that aims to develop the full potential of students, including their cognitive, affective, and psychomotor abilities. Through education, individuals are not only equipped with theoretical knowledge but also guided to acquire the life skills and moral values necessary to face life's challenges [1-4]. Effective education provides students with the opportunity to explore their abilities, develop creativity, and cultivate a critical mindset in understanding various phenomena occurring around them.

Meaningful learning is at the core of achieving educational goals. Meaningful learning occurs when students are able to relate new knowledge to their existing experiences so that the information received can be understood deeply and retained for a long time [5-7]. This requires educators to design appropriate learning strategies and methods so that students do not merely receive information passively but are also actively involved in the learning process. Active participation fosters critical thinking skills and encourages students to make connections between different concepts. By creating an engaging learning environment, educators can inspire curiosity and motivate students to explore subjects beyond the classroom. As a result, learning can serve as a means to build strong conceptual understanding while sharpening critical thinking skills.

The role of teachers as learning facilitators is very important. Teachers need to create a conducive, interactive, and challenging learning environment so that students are encouraged to participate actively [8-11]. Through appropriate learning approaches, such as experience-based learning, demonstrations, or collaboration, teachers can help students find meaning in every subject they learn. In this way, education serves not only as a means of transferring knowledge but also as a comprehensive process of self-development, ultimately preparing students to become independent, responsible individuals who are ready to face the various dynamics of life.

In practice, efforts to achieve meaningful learning still face challenges, as seen in the science learning process at SD Negeri 002 Sungai Pinang. Learning in the fourth grade is still dominated by conventional methods such as lectures and simple discussions, so that students tend to be passive and only receive information without active involvement. This condition has an impact on their low understanding of abstract concepts, especially on the subject of force, which should be learned through more contextual and interactive learning experiences.

This problem also affects students' motivation to learn. The lack of variety in teaching methods makes the learning process feel monotonous, thereby reducing students' interest and enthusiasm to participate optimally in learning activities. Therefore, innovative teaching strategies are needed that can provide concrete learning experiences while facilitating active student participation [12-14]. Demonstration methods are a relevant alternative because they allow students to directly observe the application of concepts being studied, thereby enhancing conceptual understanding and stimulating their motivation to learn.

Based on these issues, systematic efforts are needed to test the effectiveness of demonstration methods in improving the quality of science learning in elementary schools. This approach is expected to not only improve students' conceptual understanding but also increase their active involvement in the learning process. By involving students directly through demonstrations and observation, demonstration methods are believed to be able to bridge abstract concepts to make them more concrete and easier to understand.

In line with this, this study aims to (1) improve fourth-grade students' understanding of the concept of force through the application of the demonstration method and (2) analyze the extent to which the demonstration method can improve students' learning outcomes in science learning. Thus, the results of this study are expected to provide practical contributions to the development of more effective and applicable learning strategies in elementary schools.

2. Materials and Methods

This study used a Classroom Action Research (CAR) approach with the Kemmis and McTaggart model, which was implemented in two cycles [15-17]. This model was chosen because it provides opportunities for teachers to plan, implement, observe, and reflect on the learning process systematically so that improvements can be made in each cycle. The research subjects were 26 fourth-grade students at SD Negeri 002 Sungai Pinang, with a focus on improving their learning outcomes in the subject of force through the application of the demonstration method.

Each cycle in this study consisted of four main stages. In the planning stage, the researcher prepared a lesson plan (RPP), prepared teaching aids for demonstrations, and developed appropriate evaluation instruments. The implementation stage was carried out by teaching the material using interactive demonstration methods. Next, the observation stage is carried out by observing student engagement in learning and teacher performance during the process. In the reflection stage, the results of observation and evaluation are analyzed to identify shortcomings, which are then used as a basis for improvement in the next cycle.

The research instruments used included formative tests to measure student understanding and observation sheets to evaluate student engagement and teacher performance. The data obtained were analyzed descriptively and quantitatively by calculating the percentage of learning completeness in each cycle. The Minimum Learning Completion Standard (SKBM) used is 72, so students with scores equal to or above this number are considered to have completed the learning process, while those with scores below it is considered not yet completed.

3. Results

This study produced findings that illustrate the impact of applying the demonstration method on improving student learning outcomes in the subject of force. The data obtained provide an overview of the development of students' conceptual understanding from the first cycle to the second cycle, as well as showing changes in their level of engagement in the learning process. An analysis of these results was conducted to understand how the demonstration method contributes to creating more interactive, concrete, and meaningful learning for elementary school students.

3.1. Cycle I

In cycle I, learning was conducted by applying the demonstration method to the subject of force, in which the teacher demonstrated several examples of the application of force in everyday life using simple teaching aids. This activity aimed to provide students with a more concrete learning experience. However, student involvement in the learning process was still limited; most students only paid attention without actively asking questions or discussing. Based on the evaluation results, student learning achievement showed that out of 26 students, only 15 students (58%) achieved a score above the Minimum Learning Achievement Standard (SKBM) of 72, while the remaining 11 students (42%) did not meet the standard, as shown in Table 1. These results indicate the need for improvements in strategies in the next cycle to enhance student engagement and understanding more evenly.

Table 1. Student Learning Outcomes in Cycle I

Criteria	Number of Students	Percentage
Achieved (≥ 72)	15	58%
Not Achieved (< 72)	11	42%

During the learning process, student engagement remained low. Most students did not actively ask questions or respond when asked to discuss. Observations also showed that students' attention to the demonstrations conducted by teachers was not optimal, so that some of them still had difficulty relating the demonstrations to the theoretical concepts learned. This indicates the need to improve delivery strategies, particularly in involving students directly in demonstration activities.

The results of the reflection at the end of cycle I confirmed that increasing student engagement was the main focus for improvement in the next cycle. Teachers needed to create more participatory activities, provide clearer instructions during demonstrations, and provide opportunities for students to actively engage in observation and discussion. These improvements were expected to encourage better conceptual understanding and increase the learning completion rate in the next cycle.

3.2. Cycle II

In cycle II, learning was carried out by making improvements based on reflections from the previous cycle. Teachers optimized the use of demonstration methods by involving students more actively, both in observation and group discussions, and provided opportunities for them to conduct simple experiments directly. This approach succeeded in creating a more interactive learning atmosphere, so that students appeared more enthusiastic in following the learning process. The results achieved in this cycle are shown in Table 2.

Table 2. Student Learning Outcomes in Cycle II

Criteria	Number of Students	Percentage
Achieved (≥ 72)	22	85%
Not Achieved (< 72)	4	15%

The results of the evaluation in cycle II showed a significant increase in student learning achievement. Of the 26 students, 22 students (85%) achieved learning completeness with a minimum score of 72, while only 4 students (15%) did not. This increase reflects that the demonstration method applied with participatory strategies was able to help students understand the concept of force better.

Reflections at the end of the cycle indicate that active student involvement in learning, supported by clear demonstrations and opportunities for direct exploration, were the main factors contributing to improved learning outcomes. Thus, the demonstration method has proven effective in enhancing conceptual understanding while also fostering students' motivation to learn science in elementary school.

3.3. Comparison of Results in Cycle I and Cycle II

Based on the results obtained in cycle I and cycle II, there is a significant difference. This comparison can be seen in Figure 1 below.

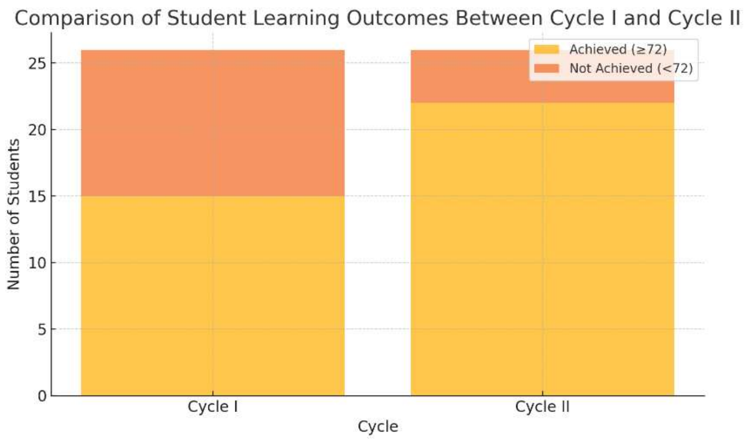

Figure 1. Comparison of Student Learning Outcomes Between Cycle I and Cycle II

A comparison of learning outcomes between cycle I and cycle II show a significant improvement in student learning completeness after improvements were made to the learning strategy. In cycle I, although the demonstration method was applied, student involvement was still limited, so learning outcomes did not reach the optimal target. Only 58% of students achieved the Minimum Learning Completion Standard (SKBM). Based on reflection on these results, improvements were made in Cycle II by emphasizing active student involvement through group discussions, direct participation in simple experiments, and clearer guidance from teachers during the demonstration process. These improvements had a positive impact, as evidenced by an increase in learning completeness to 85%. This improvement indicates that more participatory and contextual learning can provide more meaningful learning experiences for students.

4. Discussion

The results in cycle I indicate that the application of the demonstration method in science learning has not fully provided an optimal impact on students' understanding. Although this method allows teachers to demonstrate concepts concretely, student involvement in the learning process is still low, so their conceptual understanding is not yet uniform [18-20]. In other words, when students only play the role of passive observers, knowledge transfer does not run optimally.

This phenomenon also supports previous research findings that suggest that the demonstration method requires supporting strategies such as clear instructions, group discussions, and opportunities for independent exploration so that students truly understand the concepts being demonstrated [14, 21, 22]. In cycle I, limited interaction and opportunities for students to participate resulted in most of them being unable to connect the demonstration results with the theoretical concepts of style. This was reflected in the low learning completeness, with only 58% of students achieving scores above the Minimum Learning Completeness Standard (SKBM).

This condition indicates the need for improvements in the implementation of the demonstration method, particularly in enhancing students' active engagement during the learning process. Demonstrations that directly involve students can make learning more meaningful and help them build a deeper understanding [23-25]. Therefore, reflections on Cycle I emphasize the importance of modifying learning strategies, such as giving students a greater role in conducting simple experiments and holding discussions to clarify the concepts learned.

The results in cycle II showed a significant increase in student learning completeness, which rose to 85%. Improvements in strategy in this cycle included increased interaction during demonstrations, providing opportunities for students to be directly involved in simple experiments, and strengthening group discussions, which proved to be effective in improving their understanding of the concept of force [26-28].

This approach made learning more participatory, so that students were no longer passive observers but were actively involved in the process of discovering and understanding the concepts being studied. This improvement reinforced the view that the demonstration method can be an effective strategy for concretizing abstract concepts in science learning, especially when students are given the opportunity to connect practical experiences with theory [21, 29].

Additionally, student activity during the learning process positively impacts their learning motivation, resulting in a significant increase in emotional and cognitive engagement in learning [30-32]. Thus, the results of Cycle II confirm the importance of the teacher's role as a facilitator capable of creating interactive and meaningful learning experiences for students.

Overall, the improvements made in cycle II prove that the implementation of the demonstration method combined with a participatory approach can have a real impact on student learning outcomes. This achievement aligns with the view that active student involvement in learning contributes to improved conceptual understanding and better academic achievement [33-35]. Therefore, this method is worth considering as an alternative learning strategy to enhance the quality of science education in elementary schools.

The results showed an increase in student learning completeness after the application of the demonstration method from cycle I to cycle II. In cycle I, although the teacher had used the demonstration method to introduce the concept of force, student involvement was still low. Many students tended to be passive, only observing without asking questions or engaging in discussion, so their conceptual understanding was not yet uniform. This is in line with the view that demonstrations will only be effective if students are actively involved in observation and reasoning during the activity [36-38]. The low level of interaction in cycle I had an impact on learning outcomes, with only 58% of students achieving scores above the Minimum Learning Completion Standard (SKBM).

Reflection on the findings in cycle I became the basis for improvements in cycle II, namely by increasing interaction in demonstration activities, providing opportunities for students to be directly involved in simple experiments, and strengthening group discussion sessions. These changes had a positive impact, as indicated by an increase in learning completeness to 85%. These results reinforce the finding that participatory demonstration methods can concretize abstract concepts while improving student understanding [39]. Additionally, active involvement in the learning process contributes to increased student motivation, making them more enthusiastic and confident in mastering the material taught [40].

Overall, the comparison of the results of the two cycles proves that improvements in the implementation strategy of the demonstration method have a significant impact on student learning outcomes. Active involvement in learning encourages students to connect practical experiences with theory, thereby deepening their conceptual understanding. These findings reinforce the view that a learning approach that facilitates student participation can improve academic outcomes while creating a more meaningful learning experience [41-43]. Therefore, the demonstration method is worth considering as an alternative learning strategy to improve the quality of science education in elementary schools.

5. Conclusions

The findings of this study indicate that the implementation of the demonstration method effectively improved students' conceptual understanding and learning outcomes in science, particularly on the topic of force. The percentage of students achieving the Minimum Learning Completion Standard (SKBM) increased significantly from 58% in cycle I to 85% in cycle II, demonstrating that participatory and contextual demonstration activities provide a more meaningful learning experience. These results highlight the importance of designing science lessons that are not only informative but also actively engage students in exploring and observing concepts firsthand, thereby deepening their understanding and retention of abstract scientific concepts.

Based on these findings, it is recommended that teachers continue to develop and implement demonstration-based teaching strategies, complemented by interactive discussions and opportunities for students to conduct simple experiments. This approach can foster greater student motivation, engagement, and confidence in learning science. The implications of this research extend beyond classroom practice, offering valuable insights for curriculum developers and educational policymakers to promote more experiential and student-centered learning models in elementary science education. Future research could explore the integration of demonstration methods with digital media or collaborative learning to further enhance their effectiveness in various learning contexts.

Conflicts of Interest: The authors declare that there are no conflicts of interest regarding the publication of this article.

References

[1] K. Sethi, *Life Skills Education*. Academic Guru Publishing House, 2024.

[2] S. Singh dan S. Agarwal, "Empowering individuals for a sustainable tomorrow: Role of life skills development," *J. Ecophysiol. Occup. Heal.*, vol. 24, no. 2, hal. 211–219, 2024. https://doi.org/10.18311/jeoh/2024/35800

[3] K. SWARGIARY, *Introduction to education: Paper Code: EDNMAJ-101-4*. ERA, 2025.

[4] R. P. Septianti, R. R. Pelani, R. Pakosmawati, dan A. I. Irvani, "ANALISIS ATTENTION RELEVANCE CONFIDENCE SATISFACTION (ARCS) FISIKA SISWA SMA," *INPAFI (Inovasi Pembelajaran Fis.*, vol. 11, no. 01, Feb 2023, doi: 10.24114/INPAFI.V11I01.44246.

[5] S. K. Carpenter, S. C. Pan, dan A. C. Butler, “The science of effective learning with spacing and retrieval practice,” *Nat. Rev. Psychol.*, vol. 1, no. 9, hal. 496–511, 2022. https://doi.org/10.1038/s44159-022-00089-1

[6] A. Marougkas, C. Troussas, A. Krouska, dan C. Sgouropoulou, “Virtual reality in education: a review of learning theories, approaches and methodologies for the last decade,” *Electronics*, vol. 12, no. 13, hal. 2832, 2023. https://doi.org/10.3390/electronics12132832

[7] R. E. Mayer, “The past, present, and future of the cognitive theory of multimedia learning,” *Educ. Psychol. Rev.*, vol. 36, no. 1, hal. 8, 2024. https://doi.org/10.1007/s10648-023-09842-1

[8] M. Jumabaeva, “ENCOURAGING AND MOTIVATING STUDENTS TO BE ACTIVE IN THE PRIMARY SCHOOL CLASSROOM,” *Int. J. Artif. Intell.*, vol. 1, no. 2, hal. 243–245, 2025. https://inlibrary.uz/index.php/ijai/article/view/73547

[9] D. Khodadad, “Creating a supportive and effective learning environment for engineering students: Pedagogical strategies, engagement, and enhanced outcomes,” *Int. J. Eng. Pedagog.*, vol. 13, no. 8, hal. 33–50, 2023.

[10] S. B. Prapulla, C. S. KN, dan D. U. CN, “A closer look at the incorporation of pedagogy aided with technology for Creating Conducive Learning Environment,” *J. Eng. Educ. Transform.*, hal. 842–848, 2024.

[11] S. H. Heryanto, S. Aprianti, R. R. Pelani, dan A. I. Irvani, “Penggunaan E-learning Madrasah dalam Proses Pembelajaran Fisika di MAN 2 Garut,” *J. Pendidik. dan Ilmu Fis.*, vol. 3, no. 1, hal. 172–178, 2023, doi: 10.52434/jpif.v3i1.1962.

[12] A. T. Ampa, “Innovative learning strategies to increase students’ participation and quality of english teaching and learning process,” *Tech. Soc. Sci. J.*, vol. 26, hal. 314, 2021.

[13] A. H. S. Dzaiy dan S. A. Abdullah, “The use of active learning strategies to foster effective teaching in higher education institutions,” *Zanco J. Hum. Sci.*, vol. 28, no. 4, hal. 328–351, 2024.

[14] A. I. Irvani, R. Warliani, dan S. A. Fauziyyah, “Analysis of Students Problem Solving Skill from Online Worksheets with Integration of Video Demonstration,” *Proceeding ISETH (International Summit Sci. Technol. Humanit.*, hal. 140–144, 2020, Diakses: 18 Januari 2025. [Daring]. Tersedia pada: https://proceedings.ums.ac.id/iseth/article/view/1282

[15] G. A. Sari, Y. Ratnasari, dan A. I. Irvani, “Enhancing Elementary Students’ Cognitive Skills on Time Units Through the NHT Cooperative Learning Model with Analog Clock Media | Journal of Educational Innovation and Technology,” *J. Educ. Innov. Technol.*, vol. 1, no. 1, hal. 1–11, Mar 2025, Diakses: 29 Juli 2025. [Daring]. Tersedia pada: https://journal.sigufi.com/index.php/jeit/article/view/2

[16] R. R. Amarulloh dan A. I. Irvani, *Metode Penelitian Kuantitatif dalam Pendidikan: Sebuah Panduan Praktis*. PT. Sigufi Artha Nusantara, 2025.

[17] J. W. Creswell, “Educational Research: Planning, Conducting, and Evaluating Quantitative and Qualitative Research,” Pearson. Diakses: 1 November 2023. [Daring]. Tersedia pada: https://www.pearson.com/en-us/subject-catalog/p/educational-research-planning-conducting-and-evaluating-quantitative-and-qualitative-research/P200000000920/9780136874416

[18] J. Uwamahoro, K. Ndihokubwayo, M. Ralph, dan I. Ndayambaje, “Physics students’ conceptual understanding of geometric optics: Revisited analysis,” *J. Sci. Educ. Technol.*, vol. 30, no. 5, hal. 706–718, 2021.

[19] M. Mohzana, I. Israwaty, S. Cindy Sandra Lumingkewas, T. Abdul Tahir, dan A. Ilham Arief, “The Effectiveness Analysis of Android Based E-Diagnostic Test Development Program to Identify Level of Student’s Misconception,” *J. Educ.*, vol. 6, no. 1, hal. 1363–1368, 2023.

[20] P. A. Edelsbrunner *et al.*, “The relation of representational competence and conceptual knowledge in female and male undergraduates,” *Int. J. STEM Educ.*, vol. 10, no. 1, hal. 44, 2023.

[21] T. Adhikari, “Enhancing Quality of Basic Level Education through Demonstration Method,” *Triyuga Acad. J.*, vol. 3, no. 1, hal. 190–207, 2024.

[22] N. S. Rahayu, P. R. Lestari, W. N. Ady, dan A. I. Irvani, “Pengenalan Eksperimen Fisika Sederhana Kepada Siswa Kelas VI di SDN 2 Limbangan Timur,” *JPM J. Pengabdi. Masy.*, vol. 1, no. 2, hal. 76–84, 2022, doi: 10.52434/jpm.v1i2.1817.

[23] T. Xu *et al.*, “From recorded to AI-generated instructional videos: A comparison of learning performance and experience,” *Br. J. Educ. Technol.*, vol. 56, no. 4, hal. 1463–1487, 2025.

[24] E. A. Abedi, “Tensions between technology integration practices of teachers and ICT in education policy expectations: implications for change in teacher knowledge, beliefs and teaching practices,” *J. Comput. Educ.*, vol. 11, no. 4, hal. 1215–1234, 2024.

[25] D. T. K. Ng, E. H. L. Ng, dan S. K. W. Chu, “Engaging students in creative music making with musical instrument application in an online flipped classroom,” *Educ. Inf. Technol.*, vol. 27, no. 1, hal. 45–64, 2022.

[26] A. Henukh, D. D. Rochintaniawati, R. Riandi, A. Setiawan, A. I. Irvani, dan R. Q. Aini, “Environmental Physics Learning: Implementation and Assessment in Higher Education,” *Kasuari Phys. Educ. J.*, vol. 7, no. 2, hal. 269–279, 2024, doi: 10.37891/kpej.v7i2.613.

[27] V. S. Syahdah dan A. I. Irvani, “Kesulitan Menanamkan Jiwa Percaya Diri terhadap Kemampuan Mengerjakan Soal Fisika,” *J. Pendidik. dan Ilmu Fis.*, vol. 3, no. 1, hal. 163–171, 2023, doi: 10.52434/jpif.v3i1.1586.

[28] N. W. U. Widiastuti dan D. B. K. N. S. Putra, “Video Pembelajaran IPA Berbasis Demonstrasi untuk Kelas IV Sekolah Dasar,” *Mimb. Ilmu*, vol. 27, no. 2, hal. 270–278, 2022.

[29] R. Mulvia dan I. F. Lestari, "PHYSICS DEMONSTRATION VIDEOS ON YOUTUBE (PDVY) SEBAGAI MEDIA PEMBELAJARAN FISIKA BERBASIS EKSPERIMEN," in *Prosiding Seminar Nasional Universitas Jabal Ghafur*, 2023, hal. 222–227.

[30] M. Singh, P. S. James, H. Paul, dan K. Bolar, "Impact of cognitive-behavioral motivation on student engagement," *Heliyon*, vol. 8, no. 7, 2022.

[31] Y. Liu, S. Ma, dan Y. Chen, "The impacts of learning motivation, emotional engagement and psychological capital on academic performance in a blended learning university course," *Front. Psychol.*, vol. 15, hal. 1357936, 2024.

[32] J. Iqbal, M. Z. Asghar, M. A. Ashraf, dan X. Yi, "The impacts of emotional intelligence on students' study habits in blended learning environments: the mediating role of cognitive engagement during COVID-19," *Behav. Sci. (Basel).*, vol. 12, no. 1, hal. 14, 2022.

[33] U. D. Agwu dan J. Nmadu, "Students' interactive engagement, academic achievement and self concept in chemistry: an evaluation of cooperative learning pedagogy," *Chem. Educ. Res. Pract.*, vol. 24, no. 2, hal. 688–705, 2023.

[34] A. S. Munna dan M. A. Kalam, "Impact of active learning strategy on the student engagement," *GNOSI an Interdiscip. J. Hum. theory Prax.*, vol. 4, no. 2, hal. 96–114, 2021.

[35] Z. Y. Wong, G. A. D. Liem, M. Chan, dan J. A. D. Datu, "Student engagement and its association with academic achievement and subjective well-being: A systematic review and meta-analysis.," *J. Educ. Psychol.*, vol. 116, no. 1, hal. 48, 2024.

[36] A. Ariyana, I. S. Ramdhani, dan S. Sumiyani, "Merdeka Belajar melalui penggunaan media audio visual pada pembelajaran Menulis Teks Deskripsi," *Silampari Bisa J. Penelit. Pendidik. Bhs. Indones. Daerah, Dan Asing*, vol. 3, no. 2, hal. 356–370, 2020.

[37] N. S. Nurroniah, A. I. Irvani, dan S. N. Muhajir, "Contextual Problem Based Learning Model to Improve Students Critical Thinking Skill in Physics Learning," *Kasuari Phys. Educ. J.*, vol. 8, no. 1, hal. 174–186, 2025.

[38] A. I. Irvani dan A. S. Anisah, "Infrastructure and Innovation: Rethinking Digital Literacy for K-12 Learners," *Sinergi Int. J. Educ.*, vol. 2, no. 4, hal. 253–264, 2024.

[39] S. Ramankulov, I. Usembayeva, D. K. Berdi, B. Omarov, dan B. B. N. Shektibayev, *Formation of the Creativity of Students in the Context of the Education Informatization*. 2016.

[40] Y. V Yechkalo, *Methods of learning of computer simulation of physical processes and phenomena in university*. 2018.

[41] N. Ramos-Vallecillo, V. Murillo-Ligorred, dan R. Lozano-Blasco, "University students' achievement of meaningful learning through participation in thinking routines," *Eur. J. Investig. Heal. Psychol. Educ.*, vol. 14, no. 4, hal. 1012–1027, 2024.

[42] C. M. Amerstorfer dan C. Freiin von Münster-Kistner, "Student perceptions of academic engagement and student-teacher relationships in problem-based learning," *Front. Psychol.*, vol. 12, hal. 713057, 2021.

[43] M. O. Edwards-Fapohunda dan M. A. Adediji, "Sustainable development of distance learning in continuing adult education: The impact of artificial intelligence," *IRE Journals*, vol. 8, no. 1, hal. 113–114, 2024.