Journal of Research in Instructional
e-ISSN: 2776-222X
Vol. 6(1) 2026, pp. 426 – 436
https://doi.org/10.30862/jri.v6i1.67

The effectiveness of using the teachy digital application on elementary school students' science achievement

Muhammad Noryanto*, Oktaviani Adhi Suciptaningsih, Riska Pristiani

Universitas Negeri Malang, Indonesia

Submitted: 25-09-2025

Accepted: 17-02-2026

Published: 30-06-2026

Abstract: Low engagement and conventional instruction remain obstacles in Indonesian elementary science. This study examined the effectiveness of Teachy**,** a technology-enhanced learning application, in Grade-5 science. A quasi-experimental nonequivalent control group design was implemented at SDN V 013 Tana Tidung (N=33). The experimental class (n=17) learned with Teachy (interactive quizzes, animations, automated feedback); the control class (n=16) received conventional teaching. Outcomes were measured with a validated 25-item multiple-choice post-test; student engagement was observed during lessons. Assumptions of normality (Kolmogorov–Smirnov/Shapiro–Wilk) and homogeneity (Levene) were met; analyses used independent samples t-tests (α=.05). Results showed higher performance for Teachy (M=83.6, SD=6.8) than control (M=74.2, SD=7.5), t(31)=3.776, p<.001, mean difference=9.40, 95% CI [4.32, 14.48], Hedges' g=1.28 (large)**.** Findings indicate that Teachy substantially improves science achievement and supports constructivist learning aligned with the Merdeka Curriculum. Implications include integrating Teachy as core media with formative monitoring; future studies should extend to multi-site, pretest–posttest designs and retention tests.

Keywords: Engagement, science achievement, technology-enhanced learning

Abstrak: Rendahnya keterlibatan dan dominasi metode konvensional masih menjadi kendala pada pembelajaran IPA di SD. Penelitian ini menguji efektivitas Teachy sebagai *technology-enhanced learning* pada siswa kelas V. Desain yang digunakan ialah quasi-experimental nonequivalent control group di SDN V 013 Tana Tidung (N=33): kelas eksperimen (n=17) menggunakan Teachy (kuis interaktif, animasi, *automated feedback*), sedangkan kelas kontrol (n=16) belajar secara konvensional. Hasil belajar diukur dengan post-test pilihan ganda 25 butir yang tervalidasi; keterlibatan siswa diobservasi selama pembelajaran. Asumsi normalitas (Kolmogorov–Smirnov/Shapiro–Wilk) dan homogenitas (Levene) terpenuhi; analisis menggunakan independent samples t-test (α=.05). Nilai rerata eksperimen 83,6±6,8 lebih tinggi daripada kontrol 74,2±7,5**;** t(31)=3,776, p<.001, selisih rerata=9,40, CI 95% [4,32; 14,48], Hedges' g=1,28 (efek besar)**.** Temuan menegaskan bahwa Teachy meningkatkan hasil belajar IPA dan selaras dengan pendekatan konstruktivis serta Kurikulum Merdeka. Implikasi: integrasikan Teachy sebagai media inti disertai pemantauan formatif; riset lanjutan perlu desain *pretest–posttest* multi-situs dan uji retensi.

Kata kunci: Keterlibatan, hasil belajar sains, pembelajaran berbasis teknologi

*Corresponding author: m4znoer4@gmail.com

INTRODUCTION

Elementary education serves as the foundation for developing students' basic competencies, including scientific literacy, which is essential for future engagement in science. In Indonesia, however, science education at the elementary level continues to face persistent challenges. Empirical reports indicate that students' interest, participation, and inquiry behaviors remain low, while instructional practices predominantly rely on lecture-based explanations and textbook-driven activities (Nasir et al., 2024; Sabaryati et al., 2022). Such teacher-centered approaches reduce opportunities for exploration and limit students' cognitive engagement, making abstract scientific concepts difficult to comprehend.

Preliminary observations in Grade V science classrooms further reveal that students often struggle to understand abstract material due to the lack of visual representations and limited interaction with scientific phenomena. As a result, conceptual retention becomes low (Nasir et al. 2024, Siregar et al., 2025), and scientific thinking skills do not develop optimally (Dita et al., 2023; Suhartini et al., 2026; Syahrul et al., 2026).

Various studies emphasize that technology-enhanced learning (TEL) offers significant potential to address these constraints. Digital applications, hybrid platforms, and e-learning tools provide multimodal representations simulations, animations, digital comics, and interactive modules that help visualize abstract science concepts and increase student engagement (Damopolii, 2025; Dita et al., 2024; Rahayuningsih & Setiawan, 2023; Saputro et al., 2024). Web-based tools such as PhET simulations also support inquiry by enabling students to experiment with scientific phenomena that are otherwise difficult to observe directly (Anisa & Astriani, 2022). Furthermore, research shows that interactive digital environments significantly enhance motivation, engagement, and learning outcomes compared with traditional instruction (Akatyev, 2024). These findings underscore that meaningful digital integration can strengthen higher-order thinking, enrich learning experiences, and support long-term retention among elementary students. In Grade V science learning, comprehension difficulties often emerge when students encounter abstract topics such as energy transformation, the water cycle, and environmental changes. These challenges arise from the absence of concrete examples, limited opportunities for inquiry, and a lack of interactive learning experiences that align with students' cognitive development. Therefore, adopting a digital learning model that offers visual, interactive, and inquiry-oriented experiences becomes essential to facilitate meaningful concept construction.

One promising approach is the use of interactive digital learning models that integrate constructivist pedagogy with multimedia support. Mayer (2009) Cognitive Theory of Multimedia Learning explains that the combination of verbal and visual information optimizes cognitive processing through dual channels, promoting deeper conceptual understanding. Likewise, Vygotsky (1978) Social Constructivism emphasizes that learning develops through social interaction and scaffolded experiences within meaningful contexts. Empirical findings by Lin et al. (2024) and Runniarsiti et al. (2025) further demonstrate that multimedia-based constructivist instruction enhances cognitive engagement, scientific reasoning, and problem-solving abilities in elementary students. Digital media thus function not only as delivery platforms but also as cognitive scaffolds that strengthen collaboration, exploration, and knowledge construction in science learning environments.

Among the available digital innovations, Teachy is a locally developed interactive application designed to support constructivist-based learning. Teachy integrates interactive quizzes, animations, automated feedback, and AI-generated instructional support that facilitate inquiry-oriented learning and student engagement (Rahayu et al., 2025). These technology-enhanced features are pedagogically relevant, as automated feedback and multimodal representations are known to strengthen cognitive processing, increase motivation, and promote active learning within digital learning environments. In addition, the design characteristics of Teachy align closely with the objectives of the Indonesian Merdeka Curriculum, which prioritizes critical thinking, collaboration, creative expression, and digital literacy as core competencies for 21st-century learners.

Despite this strong theoretical alignment, empirical studies on Teachy remain extremely limited, especially within the context of elementary science education in Indonesia. To date, available evidence has focused primarily on material development and classroom feasibility rather than on learning outcomes, conceptual change, or affective constructs such as motivation and engagement (Nasir et al., 2023; Rahayu et al., 2025). This stands in sharp contrast to the rapidly growing body of international research on AI-driven learning tools, which has demonstrated significant impacts on personalized learning, inquiry-based instruction, and student achievement across K–12 settings (Casal-Otero et al., 2023; Lišnić et al., 2025; Yim & Su, 2023).

The lack of empirical evidence specific to Teachy therefore creates a clear research gap, particularly regarding its effectiveness in improving conceptual understanding, enhancing motivation, and increasing student engagement in elementary science learning. This gap highlights both the urgency and novelty of the present study. By evaluating Teachy within real instructional settings, the research contributes original evidence to an emerging field in which local AI-based platforms are increasingly encouraged yet insufficiently documented. The study also advances scientific understanding of how AI-supported, multimedia-enabled inquiry learning can be leveraged to improve science education outcomes in Indonesian classrooms a topic that remains underexplored but is pedagogically and technologically significant.To address this gap, the present study investigates the implementation of a Teachy-based interactive learning model in fifth-grade science instruction. Specifically, this research examines its impact on students' engagement, motivation, and conceptual understanding. The findings are expected to contribute theoretically by strengthening the literature on constructivist and technology-enhanced learning, and practically by offering an evidence-based digital learning strategy to improve science achievement in Indonesian elementary schools.

METHOD

Research design

This study employed a quantitative approach using a quasi-experimental design, specifically the nonequivalent control group design. This design was selected because it allows classroom-based intervention under natural school conditions, where intact classes cannot be randomly reassigned (Creswell & Guetterman, 2021; Fraenkel et al., 2019). Such quasi-experimental designs are widely used in educational research to examine causal relationships while maintaining ecological validity and minimizing instructional disruption (Cook & Campbell, 1979). Two groups of fifth-grade students participated in the study. The experimental group received science instruction using the Teachy application, whereas the control group was taught using conventional, teacher-centered methods.

Participants

The study was conducted at SDN V 013 Tana Tidung and involved 33 fifth-grade students. The experimental group consisted of 17 students in Class V-A, while the control group comprised 16 students in Class V-B. The use of intact classes followed a purposive sampling procedure to maintain the authenticity of the school's instructional structure and ensure comparable learning environments between groups (Gall et al., 2015). The absence of random assignment aligns with the characteristics of quasi-experimental research, particularly when ethical and administrative considerations prevent manipulation of class composition.

Instruments

A 25-item multiple-choice test was developed to measure students' conceptual understanding of science content after the intervention. The items were validated by subject-matter experts and subsequently pilot tested. The resulting reliability coefficient (Cronbach's Alpha > 0.70) demonstrated adequate internal consistency (Tavakol & Dennick, 2011). To complement the quantitative measure, an observation sheet was utilized to record students' engagement during the learning process. Observed indicators included attentiveness during instruction, participation in group discussions, and responsiveness to teacher prompts. These observational data provided qualitative insight into students' behavioral engagement throughout the intervention.

Procedure

The study was conducted over a four-week instructional period. The experimental group received science instruction supported by the Teachy application, which features interactive quizzes, animations, and automated feedback aligned with constructivist principles. Meanwhile, the control group received traditional textbook-based and lecture-centered instruction. Both groups studied the same science topics to ensure comparability of content exposure. The learning process in both conditions was aligned with the principles of the Merdeka Curriculum, emphasizing inquiry, active learning, and hands-on exploration (Kemendikbud, 2022). At the end of the instructional period, the post-test was administered to both groups, and observational data were systematically collected throughout the lessons.

Data analysis

Data analysis was conducted in two main stages. First, descriptive statistics including mean, standard deviation, maximum, and minimum scores were computed to provide an overview of students' achievement levels. Second, inferential statistical procedures were used to evaluate the research hypotheses. The normality of score distribution for both groups was assessed using the Kolmogorov–Smirnov and Shapiro–Wilk tests, while Levene's test was employed to verify homogeneity of variances (Field, 2018). As all assumptions for parametric testing were met, an independent-samples t-test was carried out to determine whether the mean post-test scores differed significantly between the experimental and control groups. All statistical analyses were performed using SPSS version 25 with a significance threshold of $\alpha = 0.05$.

RESULTS AND DISCUSSION

After the instructional intervention was completed, post-test data were collected from both the experimental group, which used Teachy ($n = 17$), and the control group, which received conventional instruction ($n = 16$). To provide an initial overview prior to inferential testing, descriptive statistics were calculated, including the mean, standard deviation, maximum, minimum, and coefficient of variation. These results help illustrate the overall pattern of achievement differences between the two groups and support the interpretation of their performance tendencies. The presentation of descriptive findings serves as an important analytical foundation before examining statistical significance. The complete summary of descriptive outcomes is shown in Table 1, allowing a clearer comparison of student performance distributions across instructional conditions and providing a basis for further statistical interpretation.

Tabel 1. Descriptive statistics

Group	n	Mean	SD	Max	Min	Coef. Variation
Experimental (Teachy)	17	83.6	6.8	95	72	0.081
Control (Conventional)	16	74.2	7.5	86	60	0.101

As shown in Table 1, the experimental group achieved a mean score 9.4 points higher than the control group (83.6 vs. 74.2), accompanied by a lower coefficient of variation (0.081 vs. 0.101). These results indicate not only higher overall performance but also greater consistency among students who used Teachy. The reduced score variability suggests a more uniform level of conceptual understanding and overall achievement, unlike the wider distribution observed in the control group. This pattern implies that the interactive, multimedia-based learning experience may have supported students more evenly, contributing to a more stable learning outcome distribution. In addition, the descriptive results highlight initial evidence that Teachy has the potential to support stronger academic performance in elementary science learning compared to conventional instruction.

To reinforce the interpretation of the mean score differences presented above, a visual representation of the mean and 95% confidence intervals for both groups is shown in Figure 1. This visualization enables readers to observe the magnitude and direction of group score differences, as well as the extent of interval overlap, which indicates the degree of separation between distributions. The graphical display complements the numerical statistics presented in Table 1 and helps clarify the confidence and precision surrounding the estimated group means.

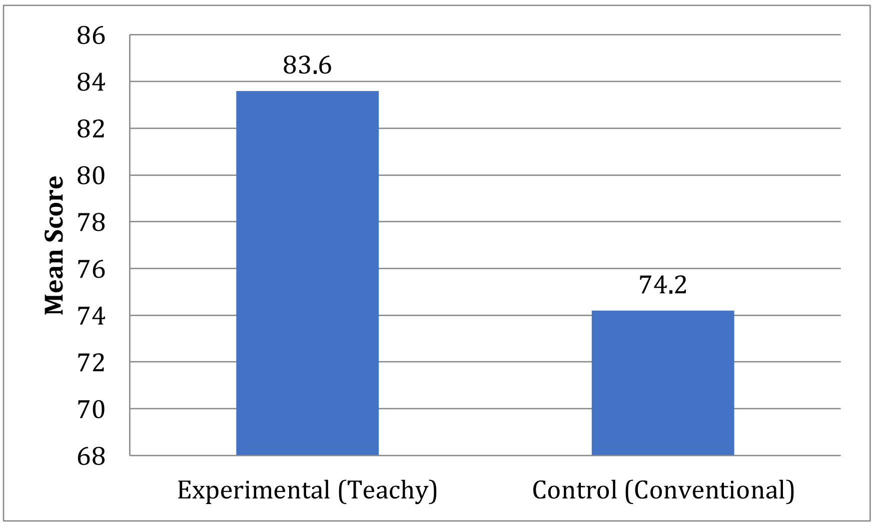

Fig. 1. Mean post-test dan CI 95%

Before applying the independent samples t-test, assumptions of normality and homogeneity of variance were examined to ensure the appropriateness of the statistical procedure. Normality was assessed using Kolmogorov–Smirnov and Shapiro–Wilk tests, while variance homogeneity was evaluated using Levene's test. These assumption checks are summarized in Table 2, allowing transparent verification that the use of parametric inferential analysis was statistically justified. The table also provides evidence that the statistical structure of the dataset aligns with the requirements for conducting an independent samples t-test with equal variances assumed.

Table 2. Assumption checks for post-test scores

Test	**Group**	**Statistic**	**df**	**p**	**Decision (α = 0.05)**
Kolmogorov–Smirnov	Experimental	0.165	17	0.200	Normal
Shapiro–Wilk	Experimental	0.949	17	0.388	Normal
Kolmogorov–Smirnov	Control	0.176	16	0.200	Normal
Shapiro–Wilk	Control	0.936	16	0.268	Normal
Levene (Equal variances)	—	F = 0.672	1, 31	0.419	Homogeneous

The assumption checks showed that both groups were normally distributed ($p > 0.05$) and exhibited homogeneous variances ($p = 0.419$), permitting the use of the independent samples t-test (two-tailed, equal variances assumed). The subsequent analysis revealed a statistically significant difference in post-test scores between the groups. To assess practical significance, multiple effect size indices were calculated. Hedges' g = 1.28 indicated a large effect; $\eta^2 = 0.315$ suggested that approximately 31.5% of the variance in post-test results was explained by Teachy; effect-size r ≈ 0.561 showed a strong association between instructional method and learning achievement; the Common Language Effect Size ≈ 82.4% indicated that a randomly selected Teachy student had an 82.4% chance of outperforming one from the control group; distribution overlap ≈ 51% suggested a clear separation between the score distributions; and relative improvement = 12.7% over the control group mean. All effect size indicators are summarized in Table 3.

Table 3. Effect size & practical significance

Metric	**Value**	**Interpretation**
Cohen's d (pooled)	1.32	Large effect
Hedges' g	1.28	Bias-corrected (large)
Variance explained (η^2)	0.315	≈ 31.5% of score variance
Effect-size r (equivalent)	0.561	Strong association
Common Language Effect Size	82.4%	Probability (student Teachy > Control)
Distribution overlap	51%	Lower overlap ⇒ clearer separation
Relative improvement vs. control	+12.7%	9.4 / 74.2 × 100

To ensure the robustness of the statistical findings, additional analyses were conducted, including comparison of the 95% confidence intervals for both groups and sensitivity testing of the equal variance assumption. These results are summarized in Table 4, providing further methodological validation and demonstrating the reliability of the findings under alternate analytical conditions. The table highlights the consistency of the statistical outcomes and confirms that the observed group differences remained stable regardless of analytical approach.

Tabel 4. Robustness & consistency checks

Component	Results	Implications
95% CI mean – Experimental	[80.4, 86.8]	High mean and good precision
95% CI mean – Control	[70.5, 77.9]	Lower than in the experiment
Overlap CI	There is almost none	Consistent with a large g (≈1.28)
Levene's test	$F(1,31)=0.672$, $p=.419$	Homogeneous variance → assumption of equal variances is valid
Sensitivity (Welch)	$t≈3.76$, $df≈30$, $p<.001$	Results remain significant without the homogeneity assumption

The robustness analysis confirmed that the statistical results were methodologically sound and internally consistent. The comparison of confidence intervals for the two groups demonstrated almost no overlap (Experimental [80.4, 86.8]; Control [70.5, 77.9]), supporting the large effect size indicated earlier (Hedges' g = 1.28). In addition, Levene's test confirmed that variances were homogeneous ($F(1,31) = 0.672$, $p = .419$), validating the equal variance assumption for the t-test. The Welch test, conducted as a sensitivity check, produced similar results ($t \approx 3.76$, $df \approx 30$, $p < .001$), further verifying the strength and stability of the findings across analytical frameworks.

The significantly higher post-test performance of the experimental group suggests that the Teachy-based learning model was substantially more effective than conventional instruction. The experimental group (M = 83.6, SD = 6.8) outperformed the control group (M = 74.2, SD = 7.5) by 9.4 points, and the effect size indicated a large practical impact ($\eta^2 = 0.315$). According to Cohen (1988) and Lakens (2013), these results meet the criteria for a large educational effect, demonstrating that more than 30% of the variance in learning achievement could be attributed to the intervention. This finding highlights the capability of digital, multimedia-supported instruction to enhance students' conceptual understanding and academic outcomes in science learning.

These findings indicate that Teachy influenced learning outcomes primarily by changing how information was presented and processed, rather than merely by adding a digital novelty. The near-complete separation of the two groups' 95% confidence intervals (experimental [80.4, 86.8] versus control [70.5, 77.9]) and the large, consistently verified effect (Hedges' $g = 1.28$, robust to the Welch sensitivity check) suggest that the advantage was systematic rather than driven by a few high-scoring students. This pattern is consistent with Mayer (2009) Cognitive Theory of Multimedia Learning, which proposes that pairing verbal and visual information supports dual-channel processing: Teachy's animations and interactive quizzes gave students a visual and manipulable representation of science content that the control group's textbook-based instruction did not provide, offering a plausible explanation for why the same test content produced such divergent achievement outcomes between groups.

The lower coefficient of variation in the experimental group (0.081 vs. 0.101 in the control group) offers a second, complementary clue about the mechanism at work. A tighter spread of scores around a higher mean suggests that Teachy's benefit was not confined to a subset of already high-performing students but extended relatively evenly across the class, which is consistent with Vygotsky (1978) emphasis on scaffolding: the application's automated feedback functions as a built-in scaffold that responds to each student's input individually, potentially narrowing the gap between initially higher- and lower-achieving students that a single, undifferentiated lecture cannot close. Because engagement was recorded only through classroom observation in this study rather than analyzed as a quantitative outcome, this scaffolding interpretation should be read as a plausible mechanism suggested by the achievement data rather than as a directly measured finding. To provide preliminary support for this mechanism, classroom observation data on students' on-task behavior during instruction were also recorded and are reported in Table 5.

Table 5. Classroom observation of student on-task behavior (experimental vs. control)

Learning Group	**Engagement Indicator**	**Mean On-Task (%)**	**Qualitative Category**	**Dominant Behavior Pattern Observed**
Experimental (Teachy, n = 17)	Attentiveness	86.5	Very High	Attention remained fixed on material animations and interactive quizzes; distraction duration was minimal.
Experimental (Teachy, n = 17)	Participation	82.4	High	Actively discussed while completing group-based gamified challenges within the application.
Experimental (Teachy, n = 17)	Responsiveness	88.2	Very High	Responded quickly to automated feedback; independently corrected incorrect answers.
Experimental (Teachy, n = 17)	Overall mean on-task	85.7	Very High	Consistent; low variation in focus distribution among students.
Control (Conventional, n = 16)	Attentiveness	68.8	Moderate	Attention easily diverted (chatting/daydreaming) while the teacher explained material on the whiteboard.
Control (Conventional, n = 16)	Participation	62.5	Moderate	Group discussions tended to be dominated by a few high-achieving students.
Control (Conventional, n = 16)	Responsiveness	56.3	Moderate	Slow to respond to probing questions due to the absence of instant answer confirmation.
Control (Conventional, n = 16)	Overall mean on-task	62.5	Moderate	Fluctuating; clear disparity in focus among students.

As shown in Table 5, the experimental group recorded a substantially higher overall mean on-task rate than the control group (85.7% vs. 62.5%), with consistently higher scores across all three indicators: attentiveness (86.5% vs. 68.8%), participation (82.4% vs. 62.5%), and responsiveness (88.2% vs. 56.3%). The qualitative field notes reinforce this pattern: Teachy students' engagement was described as consistent and evenly distributed across the class, whereas the control group's engagement was described as fluctuating and concentrated among a few high-achieving students. This observational pattern aligns with, and lends preliminary empirical support to, the scaffolding-based interpretation proposed above particularly the claim that automated feedback narrowed the engagement gap between higher- and lower-achieving students rather than benefiting only a subset of the class.

These results are broadly consistent with, and help to contextualize, prior evidence on technology-enhanced science instruction. Digital media's support for multimodal representation has been linked to stronger comprehension of abstract scientific ideas (Cheung et al., 2016), and computer-assisted instruction has repeatedly been associated with measurable gains in science achievement, particularly within active or inquiry-based designs (Erdoğan & Dede, 2015; Manik & Limbong, 2019; Milasari & Setyasto, 2023), a pattern the present effect size (g = 1.28) sits at the upper end of. Where the present findings extend this literature is in showing that this magnitude of effect can be obtained with a locally developed Indonesian platform rather than only with the international tools that dominate prior evidence (Hayanto & Hansun, 2020; Nisa et al., 2024), and that the benefit remains large even under a conservative, assumption-checked comparison rather than a simple mean difference. At the same time, because comparable studies such as Lin et al. (2024) and Zhang et al. (2024) report cognitive-engagement and reasoning gains using instruments this study did not include, the present results should be read as evidence for achievement gains specifically, with the engagement mechanism remaining an important, and testable, next question rather than an established finding of this study.

The findings underscore the potential of Teachy as a locally developed digital innovation aligned with Indonesia's Merdeka Curriculum, which emphasizes digital literacy, creativity, collaboration, and critical thinking. Teachy's gamified features and immediate feedback mechanisms reflect modern instructional design principles that prioritize inquiry, learner autonomy, and formative assessment. Therefore, the results hold meaningful implications for teachers, curriculum developers, and policymakers, demonstrating that technology-integrated instructional models can significantly strengthen the quality of elementary science learning. The adoption of platforms like Teachy may thus contribute to long-term improvements in learning effectiveness and educational transformation within Indonesian science classrooms.

CONCLUSION

The use of the Teachy application resulted in a significant improvement in fifth-grade students' science achievement compared with conventional instruction, while also reducing score variability within the class. Pedagogically, these findings align with constructivist principles, as the interactive features, animations, and automated feedback provided by Teachy supported students' conceptual understanding and learning engagement. Given these results, teachers are encouraged to integrate Teachy as a core digital learning medium and to utilize its automated feedback features for data-driven formative assessment. Nevertheless, the study has several limitations, including its nonequivalent group design, the use of a single school site, and a relatively small sample size. These limitations highlight the need for further research involving pretest–posttest designs, multi-site implementation, larger samples, and long-term retention assessments to validate and extend the present findings.

REFERENCES

Akatyev, N. (2024). Modern state of application of AI technologies in chemical education: Problems and approaches. *Bulletin of Toraighyrov University. Pedagogics Series*, *2*, 4–16. https://doi.org/10.48081/qews3041

Anisa, V., & Astriani, D. (2022). Implementation of PhET simulation with discovery learning model to improve understanding of dynamic electricity concepts. *Jurnal Pijar MIPA*, *17*(3), 292–301. https://doi.org/10.29303/jpm.v17i3.3438

Casal-Otero, L., Vázquez-Cano, E., López-Meneses, E., & Fernández-Cruz, F. J. (2023). AI literacy in K–12: A systematic review. *International Journal of STEM Education, 10*(1), 1–17. https://doi.org/10.1186/s40594-023-00418-7

Creswell, J. W., & Guetterman, T. C. (2021). *Educational Research: Planning, Conducting, and Evaluating Quantitative and Qualitative Research* (6th ed.). Pearson

Cheung, A., Slavin, R., Kim, E., & Lake, C. (2016). Effective secondary science programs: A best-evidence synthesis. *Journal of Research in Science Teaching*, *54*(1), 58–81. https://doi.org/10.1002/tea.21338

Cook, T. D., & Campbell, D. T. (1979). *Quasi-Experimentation: Design and Analysis Issues for Field Settings.* Houghton Mifflin

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences* (2nd ed.). Routledge

Damopolii, I. (2025). Student Motivation in Biology Learning Using Augmented Reality and Comics. *Report of Biological Education*, *6*(2), 76–86. https://doi.org/10.37150/11vdyg02

Dita, K. I., Nunaki, J. H., Nasir, N. I. R. F., Winarno, N., Damopolii, I., & Latjompoh, M. (2024). Flipbook digital sistem peredaran darah manusia: Dampaknya terhadap hasil belajar siswa. *Biogenesis*, *20*(2), 55–70. https://doi.org/http://dx.doi.org/10.31258/biogenesis.20.2.55-70

Dita, K. I., Tuririday, H. T., Damopolii, I., & Latjompoh, M. (2023). Designing the human circulatory system e-module to increase student achievement. *Inornatus: Biology Education Journal*, *3*(2), 75–84. https://doi.org/10.30862/inornatus.v3i2.422

Erdoğan, Y., & Dede, D. (2015). Computer assisted project-based instruction: The effects on science achievement, computer achievement and portfolio assessment. *International Journal of Instruction*, *8*(2), 177–188. https://doi.org/10.12973/iji.2015.8214a

Field, A. (2018). *Discovering Statistics Using IBM SPSS Statistics* (5th ed.). SAGE.

Fraenkel, J. R., Wallen, N. E., & Hyun, H. H. (2019). *How to Design and Evaluate Research in Education* (10th ed.). McGraw-Hill.

Gall, M. D., Gall, J. P., & Borg, W. R. (2015). *Applying Educational Research: How to Read, Do, and Use Research to Solve Problems of Practice.* Pearson.

Hayanto, N. I., & Hansun, S. (2020). Pembangunan aplikasi latihan soal IPA SD dengan gamifikasi. *Jurnal Teknologi Informasi dan Ilmu Komputer*, *7*(1), 87–98. https://jtiik.ub.ac.id/index.php/jtiik/article/view/1364

Kemendikbud. (2022). *Panduan Implementasi Kurikulum Merdeka.* Kementerian Pendidikan, Kebudayaan, Riset, dan Teknologi.

Lakens, D. (2013). Calculating and reporting effect sizes to facilitate cumulative science. *Frontiers in Psychology, 4*, 863. https://doi.org/10.3389/fpsyg.2013.00863
Lišnić, B., Zaharija, G., & Mladenović, S. (2025). Integration of artificial intelligence in K–12: Analysis of a three-year pilot study. *AI, 6*(3), 927–945. https://doi.org/10.3390/ai6030049
Lin, X. F., Wong, S. Y., Zhou, W., Shen, W., Li, W., & Tsai, C. C. (2024). Undergraduate students' profiles of cognitive load in augmented reality–assisted science learning and their relation to science learning self-efficacy and behavior patterns. *International Journal of Science and Mathematics Education*, *22*(2), 419-445. https://doi.org/10.1007/s10763-023-10376-9
Manik, E., & Limbong, T. (2019). Aplikasi pembelajaran IPA tentang fauna model game untuk sekolah dasar dengan metode computer assisted instruction (CAI). *MEANS (Media Informasi Analisa dan Sistem)*, *4*(2), 136–141. https://doi.org/10.54367/means.v4i2.547
Mayer, R. E. (2009). *Multimedia learning* (2nd ed.). Cambridge University Press.
Milasari, D., & Setyasto, N. (2023). Effectiveness of the microsoft sway assisted problem-based learning model on science learning outcomes. *Jurnal Penelitian Pendidikan IPA*, *9*(9), 7028–7035. https://doi.org/10.29303/jppipa.v9i9.4563
Nasir, N. I. R. F., Mahanal, S., Ekawati, R., Damopolii, I., Supriyono, S., & Rahayuningsih, S. (2024). Primary school students' knowledge about animal life cycle material: The survey study. *Journal of Research in Instructional*, *4*(1), 253–262. https://doi.org/https://doi.org/10.30862/jri.v4i1.320
Nasir, N. I. R. F., Purwaningsih, E., Ekawati, R., & Yambi, T. D. A. C. (2024). An analysis of primary school students' scientific literacy. *Journal of Research in Instructional*, *4*(2), 623–634. https://doi.org/10.30862/jri.v4i2.544
Nisa, K., Safitri, A., & Mubarok, H. (2024). How the evolution and track of several digital technologies in science education? *JPPS (Jurnal Penelitian Pendidikan Sains)*, *13*(2), 113–128. https://doi.org/10.26740/jpps.v13n2.p113-128
Rahayu, S., Hakim, A. R., & Fitrianingsih, N. (2025). Development of teaching materials using AI-based Teachy app at Pela Elementary School. *Journal of Educational Sciences*, *9*(5), 3788–3799. https://doi.org/10.31258/jes.9.5.p.3788-3799
Rahayuningsih, H., & Setiawan, D. (2023). PDF-based digital comic innovation: Class V human respiratory system material. *Jurnal Penelitian Pendidikan IPA*, *9*(8), 5864–5873. https://doi.org/10.29303/jppipa.v9i8.4085
Runniarsiti, R., Arismunandar, A., & Febriati, F. (2025). Development of web-based learning multimedia to improve students understanding of mathematical concepts in elementary schools. *Journal of Research in Instructional*, *5*(2), 698–713. https://doi.org/10.30862/jri.v5i2.820
Sabaryati, J., Viridi, S., Utami, L. S., Zulkarnain, & Isnaini, M. (2022). Developing motion sensor experiments in problem-based learning for students' HOTS. *Advances in Social Science, Education and Humanities Research*, 80–84. https://doi.org/10.2991/assehr.k.220129.015
Saputro, N., Patonah, S., & Sukamto, S. (2024). Designing a hybrid E-Dian application to increase the effectiveness of IPAS learning in elementary schools: Web and Android-based system design approach. *KnE Social Sciences*. https://doi.org/10.18502/kss.v9i6.15326
Siregar, N. N., Firmansyah, F., Natasya, D., & Damopolii, I. (2025). Efektivitas Project Based Learning Berbantuan Wordwall untuk Meningkatkan Prestasi Belajar Ditinjau dari Rasa Ingin Tahu. *Cokroaminoto Journal of Primary Education*, *8*(1), 32–41.

https://doi.org/10.30605/cjpe.812025.5338
Suhartini, S., Hanafi, Y., & Rahayuningsih, S. (2026). The influence of family environment on learning outcomes of grade 5 Students at SDN 002 Tana Tidung. *Journal of Research in Instructional*, *6*(1), 108–119. https://doi.org/10.30862/jri.v6i1.13
Syahrul, S., Kusumaningrum, S. R., Arifin, S., Admoko, A., & Mas'ula, S. (2026). Strengthening reading literacy through contextual teaching and learning with Dayak Belusu local wisdom. *Journal of Research in Instructional*, *6*(1), 78–91. https://doi.org/10.30862/jri.v6i1.14
Tavakol, M., & Dennick, R. (2011). Making sense of Cronbach's alpha. *International Journal of Medical Education, 2,* 53–55. https://doi.org/10.5116/ijme.4dfb.8dfd
Vygotsky, L. S. (1978). *Mind in society: The development of higher psychological processes.* Harvard University Press.
Yim, I. H. Y., & Su, J. (2023). Artificial intelligence (AI) learning tools in K–12 education: A scoping review. *Journal of Computers in Education, 10*, 1–28. https://doi.org/10.1007/s40692-023-00304-9
Zhang, W., Guan, Y., & Hu, Z. (2024). The efficacy of project-based learning in enhancing computational thinking among students: A meta-analysis of 31 experiments and quasi-experiments. *Education and Information Technologies*, *29*(11), 14513-14545. https://doi.org/10.1007/s10639-023-12392-2