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Research Article

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The Effect of Using Macromedia Flash Learning Media on Students' Higher-Order Cognitive Learning Outcomes in Physics

[1]Putri Zuhra, [2]Fatni Mufit, [2]Andromeda, [2]Lufri

[1] Doctoral Program in Science Education, Universitas Negeri Padang, Padang Indonesia
[2] Universitas Negeri Padang, Indonesia

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ABSTRACT

Higher-order cognitive ability is an important competence that needs to be developed in physics learning. However, physics instruction is still often abstract and teacher-centered, which limits its effectiveness in fostering students' thinking abilities. This study aims to examine the effect of Macromedia Flash learning media on students' higher-order cognitive ability in physics. A quasi-experimental method with a pretest–posttest control group design was employed. The study involved tenth-grade students divided into experimental and control groups. The research instrument was an essay-based test designed to measure students' higher-order cognitive ability in physics, predominantly covering the cognitive domains of analyzing (C4), evaluating (C5), and creating (C6). The data were analyzed using an independent samples t-test. The results indicate a significant difference in higher-order cognitive ability between students who learned using Macromedia Flash–based media and those who learned through conventional methods ($p < 0.05$). Therefore, Macromedia Flash learning media have a positive effect on improving students' higher-order cognitive learning outcomes in physics. The results suggest that the implementation of Macromedia Flash instructional media has the potential to effectively enhance students' higher-order thinking skills in physics education.

ABSTRAK

Kemampuan kognitif tingkat tinggi merupakan salah satu kompetensi penting yang perlu dikembangkan dalam pembelajaran fisika. Namun, pembelajaran fisika masih sering disampaikan secara abstrak dan berpusat pada guru, sehingga kurang efektif dalam mengembangkan kemampuan berpikir peserta didik. Penelitian ini bertujuan untuk menguji pengaruh media pembelajaran Macromedia Flash terhadap kemampuan kognitif tingkat tinggi peserta didik dalam fisika. Penelitian ini menggunakan metode kuasi eksperimen dengan desain pretest–posttest control group. Subjek penelitian terdiri atas peserta didik kelas X yang dibagi ke dalam kelompok eksperimen dan kelompok kontrol. Instrumen penelitian berupa tes esai yang dirancang untuk mengukur kemampuan kognitif tingkat tinggi peserta didik dalam fisika, yang didominasi oleh domain kognitif menganalisis (C4), mengevaluasi (C5), dan mencipta (C6). Data dianalisis menggunakan uji independent samples t-test. Hasil penelitian menunjukkan adanya perbedaan yang signifikan pada kemampuan kognitif tingkat tinggi antara peserta didik yang belajar menggunakan media berbasis Macromedia Flash dan peserta didik yang belajar melalui pembelajaran konvensional ($p < 0,05$). Dengan demikian, media pembelajaran Macromedia Flash memberikan pengaruh positif terhadap peningkatan hasil belajar kognitif tingkat tinggi peserta didik dalam fisika. Temuan ini menunjukkan bahwa penggunaan media pembelajaran Macromedia Flash dapat menjadi alternatif yang efektif untuk mendukung pengembangan kemampuan berpikir tingkat tinggi dalam pembelajaran fisika.

*Corresponding Author
E-mail Adress: putri.zuhra01@gmail.com

INTRODUCTION

The rapid development of educational technology has expanded the use of interactive multimedia in formal learning environments. Interactive multimedia, which integrates animations, videos, graphics, text, and other interactive elements, has been widely recognized as an effective instructional tool for enhancing learning quality. Previous studies consistently demonstrate that interactive multimedia can improve students' cognitive learning outcomes, conceptual understanding, and learning engagement across different educational levels (Muslimah et al., 2025; Tiarasari, 2021). In addition, multimedia-assisted learning has been reported to facilitate students' understanding of complex subject matter and promote active participation during the learning process (Ilahy et al., 2025; Oktariani et al., 2025). These findings suggest that interactive multimedia provides meaningful learning experiences that support students' cognitive development.

The effectiveness of interactive multimedia can be explained through the Cognitive Theory of Multimedia Learning (CTML) proposed by (Mayer, 2021). According to this theory, meaningful learning occurs when instructional materials are designed in accordance with the characteristics of human cognitive architecture, including dual-channel processing, limited working-memory capacity, and active cognitive processing. CTML further emphasizes several multimedia design principles, such as signaling, spatial and temporal contiguity, and coherence, which help learners focus on relevant information, reduce unnecessary cognitive load, and integrate new knowledge with prior understanding. Consequently, well-designed multimedia learning environments can facilitate deeper learning processes and support the development of higher-order cognitive skills.

Physics education is a subject that significantly contributes to developing students' scientific reasoning and problem-solving skills, which are essential competencies in the 21st century (Anderson & Krathwohl, 2001). However, in many schools, physics is still taught using traditional, teacher-centered approaches, limiting students' cognitive engagement in the learning process (Arsyad, 2020). Consequently, students often experience difficulties in developing higher-order cognitive skills, particularly in analyzing, evaluating, and creating solutions to physics-related problems. This challenge is reflected in the results of the 2018 Programme for International Student Assessment (PISA), which revealed that Indonesian students performed below the OECD average, especially on tasks requiring reasoning and problem-solving skills (OECD, 2019). These findings emphasize the need for innovative instructional approaches that can effectively promote students' higher-order thinking skills in physics learning (Chasanah et al., 2019).

Responding to this challenge, technology-assisted learning media have emerged as a promising alternative in science education. Interactive multimedia provides visual and interactive learning experiences through images, animations, videos, and other digital features that help students understand abstract physics concepts and improve cognitive learning outcomes (Fitriani et al., 2025; Malik et al., 2022). According to multimedia learning theory, combining text, images, and animations can optimize information processing within students' memory systems (Mayer, 2021). Moreover, meaningful and engaging learning environments facilitated by instructional media can promote the development of higher-order cognitive skills, particularly the abilities to analyze, evaluate, and create, which are recognized as the highest cognitive processes in the revised Bloom's taxonomy (Anderson & Krathwohl, 2001; Arsyad, 2020).

Macromedia Flash has been widely utilized as a platform for developing interactive multimedia in physics education (Amelia et al., 2021). The platform enables the integration of animations, simulations, audio, and interactive features that support engaging learning experiences. Through visual and interactive representations, multimedia environments can facilitate students' understanding of complex and abstract concepts while promoting active cognitive engagement during learning (Mayer, 2021). Previous studies have reported that Flash-based learning media contribute positively to students' conceptual understanding and learning outcomes in physics (Amelia et al., 2021; Sriyanto & Sukarelawan, 2021). Furthermore, the pedagogical value of such multimedia lies in its ability to support visualization, interaction, and active exploration of learning content, which are essential for meaningful learning.

The relevance of learning media assisted by Macromedia Flash lies in their instructional characteristics rather than the software platform itself. Interactive multimedia environments provide visual and dynamic representations that can support students in understanding abstract physics concepts and engaging more actively in learning activities. From the perspective of the Cognitive Theory of Multimedia Learning, the effectiveness of multimedia instruction depends on how information is presented to facilitate active cognitive processing and reduce extraneous cognitive load (Mayer, 2021). Consequently, examining the effectiveness of learning media assisted by Macromedia Flash remains important for understanding the contribution of interactive multimedia to students' higher-order cognitive skills.

Despite the growing body of research on multimedia learning, previous studies have predominantly examined conceptual understanding, learning motivation, and overall academic achievement. As a result, the extent to which multimedia-assisted learning media contribute to higher-order cognitive processes, particularly analyzing (C4), evaluating (C5), and creating (C6), remains insufficiently understood. Moreover, existing evidence has not yet provided a comprehensive picture of how Macromedia Flash-based instructional media support the development of these cognitive skills in physics learning. Therefore, further investigation is needed to clarify the role of interactive multimedia features in promoting higher-order thinking skills.

This study contributes to the existing literature by extending the investigation of multimedia-assisted learning beyond general learning achievement and conceptual understanding toward higher-order cognitive skills in physics. Specifically, the study evaluates the influence of learning media assisted by Macromedia Flash on students' abilities to analyze, evaluate, and create, which represent the upper levels of the revised Bloom's taxonomy. The study also provides empirical evidence regarding the instructional potential of interactive multimedia features embedded in Macromedia Flash for supporting cognitively demanding learning outcomes in senior high school physics education.

Based on the discussion above, this study specifically aims to determine whether there is a significant effect of using Macromedia Flash-based learning media on students' higher-order cognitive learning outcomes in physics compared with conventional learning. In particular, this study seeks to compare the higher-order cognitive performance of students who learned using Macromedia Flash-based media and those who learned through conventional instruction.

The findings are expected to provide theoretical contributions to the development of interactive multimedia-based physics learning research. Furthermore, the results may serve as empirical guidance for physics teachers in selecting effective instructional media to enhance students' higher-order thinking skills. Practically, the outcomes of this study are anticipated to support the implementation of innovative physics teaching approaches that prioritize the development of students' abilities.

RESEARCH METHOD

This study employed a quantitative approach using a quasi-experimental pretest–posttest control group design. The participants were tenth-grade students selected from two classes using cluster random sampling from the population of Grade X students. One class was assigned as the experimental group and received instruction through Macromedia Flash-based learning media, whereas the other class served as the control group and received conventional instruction consisting of teacher explanations, textbook-based learning activities, classroom discussions, and problem-solving exercises without interactive multimedia support. The use of intact classes was consistent with the quasi-experimental design and helped maintain the natural classroom setting throughout the study.

The Macromedia Flash used in this study was selected and prepared based on its suitability for physics instruction, especially in presenting abstract concepts through interactive visualizations and animations. The media was considered appropriate and feasible for classroom implementation based on its relevance to the learning objectives and instructional content used in the experimental group.

The research instrument was an essay test designed to assess students' higher-order cognitive skills. The instrument was developed based on the revised Bloom's taxonomy, predominantly targeting the cognitive levels of C4 (analyzing), C5 (evaluating), and C6 (creating), with a small proportion of C3 (applying) items retained as a foundation for concept application in contextual situations. The cognitive level of each item was determined based on the operational verbs, required thinking processes, and cognitive demand of the task.

The test consisted of ten essay questions designed to assess higher-order cognitive skills. Item validity was examined using the Pearson Product Moment correlation technique, while instrument reliability was evaluated using Cronbach's Alpha coefficient. The results indicated that all items met the validity criteria and the instrument demonstrated acceptable reliability for research purposes. The distribution of the test items based on content area, indicators, and cognitive levels is presented in Table 1.

Table 1. Blueprint of HOTS-Based Test Instrument

Item No.	Content Area	Indicator	Cognitive Level	Skill Measured
1	Thermal Expansion	Analyzing experimental data to determine final length	C4	Analysis
2	Changes in Matter	Interpreting changes in states of matter	C4	Analysis
3	Heat Capacity	Determining heat capacity in context	C3	Application
4	Black's Principle	Analyzing heat equilibrium to determine temperature	C4	Analysis
5	Latent Heat	Evaluating final temperature of ice–water mixture	C5	Evaluation
6	Conduction	Formulating a hypothesis on heat conduction	C6	Creation
7	Radiation	Analyzing factors affecting heat radiation	C4	Analysis
8	Thermal Conductivity	Evaluating the junction temperature of two metals	C5	Evaluation
9	Linear Expansion	Analyzing temperature change from length increase	C4	Analysis
10	Heating Curve	Constructing a temperature–heat graph	C6	Creation

Note: C3 item was retained because it was presented in a contextual and reasoning-based format, thereby still supporting the assessment of higher-order cognitive skills.

Table 1 shows that most items were categorized at the C4–C6 levels, with only one item at the C3 level. This indicates that the instrument was primarily designed to measure higher-order cognitive skills.

The study was conducted in three stages: preparation, implementation, and evaluation. During the preparation stage, the researcher prepare the Macromedia Flash learning media and the research instruments. The implementation stage began with administering a pretest on higher-order cognitive skills to both classes, followed by the learning process conducted over several sessions. In the experimental class, instruction was delivered using the Macromedia Flash media, while the control class followed conventional teaching methods. The evaluation stage involved administering a posttest on higher-order cognitive abilities to both classes. The overall research procedure of the study is illustrated in Figure 1.

(1) Preparation Stage
Identifying research problem
Preparing Macromedia Flash-based learning media
Constructing HOTS test instrument
Validating instrument

↓

(2) Selection of Research Subjects

Experimental Class	Control Class
(X5)	(X2)

↓

(3) Pretest
Measuring students' initial higher-order cognitive skills

↓

(4) Implementation Stage

Experimental Class	Control Class
Learning using Macromedia Flash media	Conventional learning

↓

(5) Posttest
Measuring students' higher-order cognitive skills after treatment

↓

(6) Data Analysis
Descriptive statistics · Normality test
Homogeneity test · Independent-samples t-test

Figure 1. Research procedure flowchart

The collected data were analyzed using descriptive and inferential statistics. Prior to hypothesis testing, prerequisite analyses were conducted, including the normality test and homogeneity test. Hypothesis testing was then performed using an independent-samples t-test to examine whether there was a significant difference in students' higher-order cognitive skills between the experimental and control groups.

RESULTS AND DISCUSSION

Result

Descriptive Analysis of Students' Higher-Order Cognitive Learning Outcomes

The research findings were obtained from the pretest and posttest scores of students' higher-order cognitive learning outcomes in both the experimental and control classes. The descriptive statistics of the students' scores are presented in Table 2.

Table 2. Descriptive Statistics Scores

Class	N	Pretest (Mean)	Posttest (Mean)
Experimental	29	32.55	76.41
Control	29	29.97	63.69

As presented in Table 2, both the experimental and control groups exhibited comparable levels of higher-order cognitive skills prior to the intervention. Following the instructional treatment, improvements were observed in both groups; however, the experimental group demonstrated a more substantial gain than the control group. This finding indicates that the integration of Macromedia Flash-assisted learning media was effective in enhancing students' higher-order cognitive learning outcomes.

Higher-Order Cognitive Learning Outcomes Improvement According to N-Gain

To examine the extent of improvement in students' higher-order cognitive learning outcomes, N-Gain scores were calculated for both groups. The results are presented in Figure 2.

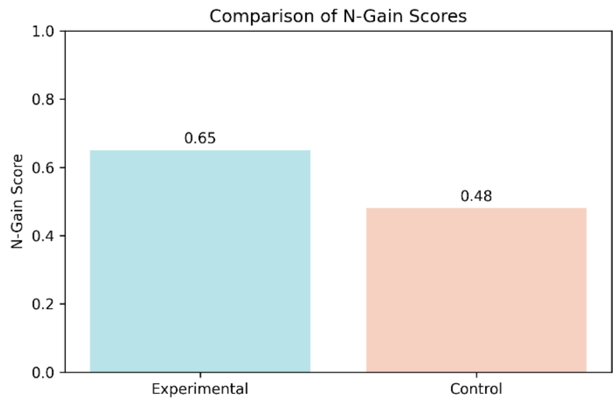

Figure 2. N-Gain Results

The N-Gain results indicate that the experimental group (0.65) achieved greater improvement than the control group (0.48). This finding suggests that learning media assisted by Macromedia Flash were more effective in improving students' higher-order cognitive learning outcomes than conventional learning.

Normality and Homogeneity Test Results

Before conducting the hypothesis testing, the posttest data were subjected to prerequisite analyses, including normality and homogeneity tests.

Table 3. Posttest Data Normality Test Results

Class	Statistik	Sig.	Results
Experimental	0.104	0.200	Normal
Control	0.153	0.079	Normal

The significance values of the normality test using the Kolmogorov-Smirnov method for both classes were greater than 0.05, indicating that the posttest data of students' higher-order cognitive learning outcomes in physics were normally distributed.

Table 4. Homogeneity of Variance Test Results

Statistik Levene	Sig.	Results
0.302	0.585	Homogen

The results of the homogeneity test show a significance value of 0.585 (> 0.05), which means that the variances of the data from both classes are homogeneous. Therefore, the data meet the requirements for conducting an independent t-test.

Hypothesis Test Results

The hypothesis was tested using an independent-samples t-test to determine the difference in Higher-Order Cognitive Learning Outcomes between the experimental and control classes.

Tabel 5. Independent-Samples t-Test Results for Posttest

Class	Mean	t-test	Sig. (2-tailed)	Results
Experi-mental	76.41	5.53	0.000	H_0 was rejected
Control	63,69			

The results of this study indicate that learning media assisted by Macromedia Flash had a significant positive effect on students' higher-order cognitive learning outcomes in physics. The independent-samples t-test revealed a significant difference between the experimental and control groups ($p < 0.05$), while the N-Gain analysis showed greater improvement in the experimental group. These findings suggest that interactive multimedia learning environments can facilitate the development of students' abilities to analyze, evaluate, and solve physics-related problems more effectively than conventional instruction.

Discussion

Interpretation of Findings Based on the Cognitive Theory of Multimedia Learning

The findings of this study can be interpreted through the Cognitive Theory of Multimedia Learning (CTML) proposed by (Mayer, 2021). The learning media assisted by Macromedia Flash incorporated animations, visual representations, and interactive simulations that enabled students to process information through both verbal and visual channels. This condition reflects the modality principle, which suggests that learning becomes more effective when information is presented through complementary forms of representation. In addition, the media design may have supported the coherence principle by emphasizing relevant information and minimizing unnecessary content, thereby reducing extraneous cognitive load.

The combination of these multimedia features likely facilitated deeper cognitive processing and helped students construct meaningful understanding of abstract physics concepts. By providing dynamic visualizations of physical phenomena, the learning media enabled students to identify relationships among concepts, evaluate information, and formulate solutions to problems. These cognitive activities are closely associated with higher-order cognitive processes and may explain the superior performance demonstrated by students in the experimental group. These findings are consistent with previous studies demonstrating the positive role of interactive multimedia in supporting meaningful learning and higher-order thinking processes (Amelia et al., 2021; Mayer, 2021).

Pedagogical Relevance of Macromedia Flash in Contemporary Physics Education

The findings of this study also highlight the continued pedagogical relevance of Macromedia Flash-assisted learning media. Although Macromedia Flash is no longer actively developed as a software platform, the findings suggest that its educational value remains relevant from an instructional perspective. The effectiveness observed in this study appears to be associated not with the technological platform itself but with the quality of the instructional design and multimedia elements incorporated into the learning process. Features such as simulations, animations, and interactive visualizations provide opportunities for students to explore abstract physics concepts in a more concrete and meaningful manner.

From a pedagogical standpoint, the learning media encouraged students to become active participants in the learning process. Students were provided with opportunities to investigate concepts independently, observe scientific phenomena through simulations, and engage in cognitive activities beyond simple memorization. Such experiences support the development of analytical and evaluative thinking, which are fundamental components of higher-order cognitive skills (Anderson & Krathwohl, 2001).

Furthermore, the findings can also be explained through Cognitive Load Theory. (Sweller et al., 2019) argue that instructional materials designed to reduce unnecessary cognitive demands can improve information processing and facilitate learning at advanced cognitive levels. In the present study, the multimedia features embedded in the learning media may have helped students focus on relevant information and process scientific concepts more efficiently, thereby supporting the development of higher-order thinking skills.

Implications for the Development of Higher-Order Cognitive Skills

The findings of this study have important implications for the development of higher-order cognitive skills in physics education. The improvement demonstrated by students in the experimental group indicates that the learning activities supported cognitive processes associated with analyzing (C4), evaluating (C5), and creating (C6), which represent the upper levels of the revised Bloom's Taxonomy (Anderson & Krathwohl, 2001). These competencies are essential because they enable students to interpret information critically, evaluate scientific evidence, and generate solutions to complex problems.

The development of these cognitive skills is particularly relevant to the challenges identified through international assessments such as PISA. OECD (2021) reported that many students continue to encounter difficulties when solving problems that require reasoning, evaluation, and scientific problem-solving. In this context, the improvement in students' abilities at the C4–C6 levels suggests that multimedia-assisted learning environments can contribute to strengthening competencies that underpin scientific literacy. By engaging students in activities that require analysis, evaluation, and creation, the learning media may help prepare them to address authentic scientific problems encountered both inside and outside the classroom.

These findings are consistent with previous studies showing that multimedia-based learning environments can enhance students' conceptual understanding and engagement through interactive visual representations of scientific concepts (Amelia et al., 2021; Mayer, 2021). Similar results were reported by (Saprudin & Hamid, 2018), who demonstrated that multimedia-assisted learning can simultaneously enhance conceptual understanding and higher-order thinking skills. Furthermore, (Eveline et al., 2019) showed that interactive media integrated with scaffolding and problem-based learning approaches can further strengthen students' higher-order cognitive development. Collectively, these studies reinforce the view that multimedia learning environments function as cognitive tools that support knowledge construction through exploration, reflection, and problem-solving activities (Hmelo-Silver, 2023; Jonassen, 2011).

Limitations and Future Research Directions

Several limitations should be considered when interpreting the findings of this study. First, the study involved a relatively small sample drawn from only two classes within a single educational setting. As a result, the findings may not fully represent students from different schools, regions, or educational backgrounds. This limitation may affect the external validity of the study and restrict the generalizability of the findings to broader populations.

Second, the duration of the intervention was relatively short, making it difficult to determine whether the observed improvements in higher-order cognitive skills would be maintained over an extended period. The effectiveness of the learning media may vary when implemented across different instructional durations, topics, and learning contexts.

Future research should involve more diverse educational contexts and physics topics to examine the consistency of multimedia-assisted learning in enhancing higher-order cognitive skills, particularly analyzing (C4), evaluating (C5), and creating (C6). Such investigations may provide stronger evidence regarding the effectiveness and generalizability of multimedia-assisted learning in supporting advanced cognitive development across different science learning environments.

CONCLUSION

Based on the results and discussion presented, it can be concluded that the use of Macromedia Flash learning media has a positive and significant effect on students' higher-order cognitive learning outcomes in physics. Learning that utilizes Macromedia Flash media is able to enhance students' thinking abilities at the levels of analysis, evaluation, and creation compared to conventional instruction.

The improvement in students' higher-order cognitive skills indicates that interactive learning media based on Macromedia Flash is effective in helping students understand abstract physics concepts through dynamic visualizations and animations. This media also promotes more active cognitive engagement in the learning process, thereby supporting the development of higher-order cognitive learning outcomes, which are essential in 21st-century education.

Therefore, Macromedia Flash learning media can serve as an innovative instructional tool in physics education to enhance students' higher-order cognitive learning outcomes. This study is expected to provide a reference for teachers and educational practitioners in effectively integrating technology-based learning media. Nevertheless, further research is needed with a broader range of topics, longer instructional duration, and a larger sample size to obtain a more comprehensive understanding of the effectiveness of Macromedia Flash media in physics learning. The findings of this study have practical implications for physics teachers. Integrating interactive multimedia learning media into classroom instruction may provide students with greater opportunities to engage in analytical, evaluative, and problem-solving activities. Therefore, teachers are encouraged to utilize multimedia-based learning environments as part of their instructional strategies to support the development of higher-order cognitive skills in physics learning.

REFERENCES

Amelia, R., Salamah, U., Abrar, M., Painan, S. M. A. N., Selatan, K. P., & Barat, S. (2021). Improving Student Learning Outcomes Through Physics Learning Media Using Macromedia Flash . *Journal of Education Technology*, *5*(3), 491–500. https://doi.org/10.23887/jet.v5i3.36203

Anderson, L. W., & Krathwohl, D. R. (2001). *A Taxonomy for Learning, Teaching, and Assessing: A Revision of Bloom's Educational Objectives* (L. W. Anderson & D. R. Krathwohl (eds.)). Longman.

Arsyad, A. (2020). *Media Pembelajaran*. RajaGrafindo Persada.

Chasanah, R. N., Mujasam, Widyaningsih, S. W., & Yusuf, I. (2019). Influence Of The Use Of Interactive Learning Media On Students ' Higher Order Thinking Skills. *Kasuari : Physics Education Journal (KPEJ) Universitas Papua*, *2*(1), 26–35. https://doi.org/10.37891/kpej.v2i1.91

Eveline, E., Ardiyati, T. K., & Dasilva, B. E. (2019). Development of Interactive Physics Mobile Learning Media for Enhancing Students ' HOTS in Impulse and Momentum with Scaffolding Learning Approach. *Jurnal Penelitian Dan Pengembangan Pendidikan Fisika*, *5*(2), 123–132. https://doi.org/10.21009/1.05207

Fitriani, W., Asyifa, R., & Bakri, F. (2025). Meaningful Learning with Digital Module : Innovation in High School Physics Learning on Waves. *Jurnal Penelitian Dan Pengembangan Pendidikan Fisika*, *August*. https://doi.org/10.21009/1.11202

Hmelo-Silver, C. E. (2023). Problem-Based Learning: What and How Do Students Learn? *Educational Psychology Review*, *35*(2), 1–19. https://doi.org/10.1007/s10648-022-09688-3

Ilahy, W. Q., Subali, B., & Widiarti, N. (2025). Kajian literatur tren penelitian pengembangan media pembelajaran interaktif berbantuan Canva pada rentang tahun 2020-2025. *Pendas : Jurnal Ilmiah Pendidikan Dasar*, *10*(1). https://doi.org/10.23969/jp.v10i01.23780

Jonassen, D. H. (2011). *Learning to Solve Problems: A Handbook for Designing Problem-Solving Learning Environments*. Routledge.

Malik, A., Wandira, A., Kuntadi, D., & Nugraha, A. R. (2022). How can interactive multimedia direct instruction model improve student cognitive learning outcomes ? *Momentum: Physics Education Journal*, *6*(2), 104–118. https://doi.org/10.21067/mpej.v6i2.6686

Mayer, R. E. (2021). *Multimedia Learning* (3rd ed.). Cambridge University Press.

Muslimah, H., Istiningsih, S., Saputra, H. H., Erfan, M., & Mataram, U. (2025). Pengaruh Media Pembelajaran Berbasis Multimedia Interaktif terhadap Hasil Belajar Kognitif IPA Siswa Kelas V SD. *Science : Jurnal Inovasi Pendidikan Matematika Dan IPA*, *5*(2), 857–865. https://doi.org/10.51878/science.v5i2.5718

OECD. (2019). *PISA 2018 Results: What Students Know and Can Do*. https://doi.org/10.1787/5f07c754-en

Oktariani, V. T., Raharjo, T. J., Sarwi, Avrilianda, D., & Subali, B. (2025). Efektivitas Penggunaan Multimedia Interaktif dalam Pembelajaran terhadap Kemampuan Kognitif Siswa Kelas V Sekolah Dasar. *Pendas : Jurnal Ilmiah Pendidikan Dasar*, *10*(01), 154–163. https://doi.org/10.23969/jp.v10i01.22517

Saprudin, & Hamid, F. (2018). Efektivitas Penggunaan Multimedia Interaktif Materi Kalor Berorientasi Peta Kompetensi Siswa Sekolah Menengah Atas. *Titian Ilmu: Jurnal Ilmiah Multi Sciences*, *10*(1), 29–38.

https://doi.org/10.30599/jti.v10i1.135

Sriyanto, & Sukarelawan, M. I. (2021). Improving the Student s ' Physics Learning Outcomes Using Macromedia Flash in SMAN 2 Bantul. *Jurnal Pendidikan Fisika*, *9*(2), 178–184. https://doi.org/10.26618/jpf.v9i2.4525

Sweller, J., Ayres, P., & Kalyuga, S. (2019). *Cognitive Load Theory*. Springer. https://doi.org/10.1007/978-1-4939-9031-3

Tiarasari, A. (2021). The effectiveness of interactive multimedia to improve cognitive skill on Elementary School Students. *JPI (Jurnal Pendidikan Indonesia)*, *10*(2), 387–395. https://doi.org/10.23887/jpi-undiksha.v8i2.17357