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THE EFFECTIVENESS OF THE USE OF MULTIMEDIA INTERACTIVE LEARNING IPAS ON THINKING SKILLS CRITICAL AND SCIENCE LITERACY IN GRADE V STUDENTS OF SD NEGERI PAKEL YOGYAKARTA

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ABSTRACT

This study aims to analyze the effectiveness of interactive IPAS learning multimedia in improving the critical thinking skills and science literacy of fifth-grade students at SD Negeri Pakel Yogyakarta. A quantitative approach with a quasi-experimental method and a pretest–posttest control group design was employed. The participants were divided into an experimental class, which used interactive IPAS learning multimedia, and a control class, which received conventional instruction. Data were collected through validated and reliable tests measuring critical thinking skills and science literacy. The data were analyzed using descriptive statistics, normality and homogeneity tests, Independent Samples t-tests, and N-Gain analysis. The results indicate that the interactive multimedia significantly improved students' critical thinking skills and science literacy. Before the intervention, no significant differences were found between the experimental and control groups in critical thinking skills ($p = 0.523$) or science literacy ($p = 0.482$). After the intervention, the experimental class achieved a significantly higher mean posttest score in critical thinking skills (72.61) than the control class (55.56) ($p < 0.001$), with an N-Gain of 0.4832 (moderate) compared to 0.1651 (low). In science literacy, the experimental class also outperformed the control class, obtaining a mean posttest score of 74.08 versus 68.92 ($p = 0.001$). The N-Gain values were 0.4945 and 0.4060, respectively, both classified as moderate, although the experimental class demonstrated greater improvement. These findings demonstrate that interactive IPAS learning multimedia is an effective instructional tool for enhancing elementary students' critical thinking skills and science literacy.

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INTRODUCTION

The development of digital technology in the 21st century has transformed education worldwide toward more interactive and learner-centered learning. The use of interactive multimedia has become a global strategy to improve science learning quality and students' critical thinking skills. Previous studies show that integrating interactive multimedia into science education enhances cognitive engagement, facilitates conceptual exploration, and promotes higher-order thinking skills such as analysis and evaluation (Widodo et al., 2025). Multimedia technology also supports multimodal learning by integrating text, images, audio, and animation to improve students' understanding of abstract scientific concepts (Lubis et al., 2021). This trend highlights digital literacy and scientific literacy as essential competencies that require innovative pedagogical approaches to prepare students for technological advancement.

In Indonesia, the implementation of the Merdeka Curriculum encourages contextual, exploratory, and project-based learning, including in Natural and Social Sciences (IPAS) at the elementary level. However, the PISA 2022 results indicate that Indonesian students' science literacy remains below the OECD average, with a mean science score of 383 compared to the OECD average of 485. Conventional, memorization-oriented instruction continues to limit students' active participation, critical thinking, and problem-solving abilities. Conversely, studies conducted in Yogyakarta and Bali demonstrate that interactive multimedia significantly improves elementary students' learning motivation, conceptual understanding, and critical thinking skills (Pradnyawati & Rati, 2023). Interactive multimedia also provides concrete visualization, scientific simulations, and inquiry-based learning experiences that foster deeper conceptual understanding (Wahyuni & Hartono, 2021).

Previous studies consistently demonstrate the effectiveness of interactive multimedia in improving learning outcomes and higher-order thinking skills. (Hasanah, 2023) reported significant improvements in students' critical thinking after using simulation-based interactive multimedia, while (Widodo et al., 2025) found that locally contextualized multimedia enhanced elementary students' science literacy. Nevertheless, most previous studies examined these outcomes separately or focused primarily on general cognitive achievement. Limited evidence is available regarding the effectiveness of interactive multimedia in simultaneously improving critical thinking skills and science literacy within elementary IPAS learning. This gap indicates the need for further investigation.

Advances in information and communication technology provide teachers with opportunities to integrate interactive multimedia that combines text, images, audio, video, and animation into meaningful learning experiences. Such multimedia encourages active learning, exploration, and scientific inquiry while supporting the development of critical thinking and science literacy.

Therefore, research is needed to examine the effectiveness of interactive multimedia in IPAS learning. Students' low critical thinking ability and limited science literacy reduce their capacity to analyze observations and draw appropriate scientific conclusions. Interactive multimedia is expected to provide contextual learning experiences through dynamic visualization, simulations, and virtual experiments that are difficult to achieve using conventional instruction alone.

This study has academic significance because it addresses the limited evidence regarding the effectiveness of interactive multimedia in simultaneously improving critical thinking skills and science literacy among elementary school students. The findings are expected to strengthen empirical evidence in IPAS learning and provide practical guidance for teachers and curriculum developers in designing adaptive, interactive, and contextual digital learning aligned with the characteristics of Indonesian students (Pratiwi & Margunayasa, 2024). Furthermore, the results may serve as a reference for educational policies supporting digital literacy and pedagogical innovation in the era of educational technology transformation.

This study aims to analyze the effectiveness of interactive multimedia in IPAS learning for improving the critical thinking skills and science literacy of fifth-grade students at SD Negeri Pakel, Yogyakarta.

METHOD

This study employed a quantitative approach using a quasi-experimental research design with a nonequivalent control group design. Experimental research is a systematic and controlled method used to examine the effect of a particular treatment on research variables (Asri, 2017; Sugiyono, 2016). The quasi-experimental design was selected because complete

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control over external variables was not feasible in the school setting while allowing the researchers to examine causal relationships between the instructional treatment and learning outcomes. This design is widely recommended for evaluating educational interventions in authentic classroom environments (Sari & Hartono, 2024).

The study involved two groups: an experimental group and a control group. Students in the experimental group received instruction using interactive IPAS learning multimedia, whereas students in the control group were taught through conventional teacher-centered instruction. The research design is presented in Table 1.

Table 1. Nonequivalent Control Group Design

Group	Pretest	Treatment	Posttest
KI	O_1	X_1	O_2
KII	O_1	–	O_2

Source: (Danuri & Maisaroh, 2019)

The population consisted of all fifth-grade students of SD Negeri Pakel Yogyakarta during the current academic year. The population comprised two classes, VA and VB, with 27 students in each class, yielding a total of 54 participants. Since the population was relatively small and fully accessible, this study employed a total sampling technique in which all members of the population participated as research subjects. The use of total sampling minimizes selection bias and ensures that the sample adequately represents the target population (Hapsari & Nugroho, 2022).

The independent variable was the use of interactive IPAS learning multimedia, while the dependent variables were students' critical thinking skills and science literacy. Data were collected through essay tests administered as pretests and posttests, supported by documentation. Documentation included lesson plans, classroom implementation records, attendance lists, and learning activities to ensure that the instructional procedures were implemented consistently throughout the study. The critical thinking instrument consisted of 12 essay items developed based on six critical thinking indicators: interpretation, analysis, inference, evaluation, explanation, and self-regulation. The items covered magnetism topics in the fifth-grade IPAS curriculum, including magnetic and non-magnetic objects, magnetic poles, magnetic force, the utilization of magnets, and magnet experiments, with cognitive levels ranging from C3 (applying) to C5 (evaluating). The distribution of the items included interpretation (Items 10 and 11), analysis (Items 2 and 4), inference (Items 6 and 9), evaluation (Items 1 and 8), explanation (Items 5 and 7), and self-regulation (Items 3 and 12).

The science literacy instrument consisted of 16 essay items representing five dimensions of scientific literacy: the role of science, thinking and doing science, science and society, mathematics in science, and motivation and beliefs about science. The instrument assessed students' ability to identify scientific questions, understand scientific concepts, explain natural phenomena, recognize patterns, identify research variables, evaluate conclusions based on evidence, interpret scientific reports, apply scientific knowledge in everyday contexts, and use mathematics in scientific situations. Similar to the critical thinking instrument, the items were developed using fifth-grade magnetism topics with cognitive levels ranging from C3 to C5.

Each essay response was assessed using an analytical scoring rubric ranging from 0 to 4, where a score of 0 indicated an incorrect or unanswered response and a score of 4 indicated a complete, accurate, and scientifically appropriate explanation. The total scores were subsequently converted to a scale of 0–100 for statistical analysis.

The intervention was implemented over four instructional meetings using the same learning objectives, instructional materials, and time allocation for both groups. Each lesson began with an introductory activity in which the teacher presented the learning objectives and motivated students. During the core learning activities, students in the experimental group explored magnetism concepts through interactive multimedia integrating text, images, animations, videos, simulations, and interactive exercises. Students observed scientific phenomena, completed multimedia-based learning tasks, discussed concepts collaboratively, and received immediate feedback. In contrast, students in the control group learned the same content through conventional teacher explanations, textbook-based instruction, classroom discussions, and worksheet activities without multimedia support. Each lesson concluded with reflection and reinforcement of the concepts that had been learned.

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Before data collection, the research instruments were examined for validity and reliability. Content validity was established through expert judgment by science education specialists to ensure that each item appropriately represented the intended indicators. Item validity was subsequently analyzed using Pearson's Product Moment correlation by correlating each item score with the total score. Items with correlation coefficients exceeding the critical r-value were considered valid. Instrument reliability was evaluated using Cronbach's Alpha coefficient, with values of 0.70 or higher indicating acceptable internal consistency.

The collected data were analyzed using descriptive and inferential statistics. Prior to hypothesis testing, the assumptions of normality and homogeneity were examined. Data normality was tested using the Kolmogorov–Smirnov test with a significance level of $\alpha = 0.05$. Data were considered normally distributed when the significance value exceeded 0.05 ($p > 0.05$). Homogeneity of variance between the experimental and control groups was examined using Levene's test, with homogeneous variances indicated by significance values greater than 0.05 ($p > 0.05$).

After the assumptions had been satisfied, hypothesis testing was conducted using the Independent Samples t-test to compare the posttest scores of the experimental and control groups. The effectiveness of the instructional treatment was further evaluated using the normalized gain (N-Gain), which measures students' learning improvement from pretest to posttest. N-Gain values were interpreted according to three categories: high ($g \geq 0.70$), medium ($0.30 \leq g < 0.70$), and low ($g < 0.30$).

RESULT AND DISCUSSION

Assumption Testing

Before hypothesis testing, the data were examined to determine whether they met the assumptions required for parametric statistical analysis. The normality of the data was assessed using the Shapiro–Wilk test, while homogeneity of variance was evaluated using Levene's test for both critical thinking skills and science literacy variables.

The results showed that all pretest and posttest data were normally distributed ($p > 0.05$), and the variances between the experimental and control groups were homogeneous ($p > 0.05$). Therefore, the assumptions for parametric analysis were fulfilled, allowing the Independent Samples t-test to be used to compare the learning outcomes between the two groups.

Critical Thinking Skills

1. Pretest

The descriptive analysis indicated that students in the experimental class obtained a minimum score of 38 and a maximum score of 56, with a mean of 47.61 (SD = 5.770). In comparison, students in the control class achieved scores ranging from 38 to 56, with a mean of 46.60 (SD = 5.695). The difference between the two groups was only 1.01 points, indicating relatively comparable initial critical thinking abilities.

The Independent Samples t-test produced a t-value of 0.643 ($df = 52$) with a significance value of 0.523 ($p > 0.05$). These findings indicate that there was no statistically significant difference between the experimental and control groups before the intervention, confirming that both groups had equivalent baseline critical thinking skills.

2. Posttest

Following the learning intervention, the experimental class achieved substantially higher posttest scores than the control class. The experimental group obtained scores ranging from 63 to 81, with a mean of 72.61 (SD = 5.770), whereas the control group obtained scores between 48 and 65, with a mean of 55.56 (SD = 4.970). The average difference between the two groups reached 17.05 points.

The Independent Samples t-test revealed a significant difference between the two groups ($t = 11.636$, $df = 52$, $p < 0.001$). These results demonstrate that students who learned using interactive IPAS multimedia achieved significantly higher critical thinking performance than students who received conventional instruction.

3. N-Gain Analysis

The normalized gain analysis showed that the experimental class obtained N-Gain scores ranging from 0.40 to 0.57, with an average of 0.4832 (SD = 0.05105). Meanwhile, the control class achieved N-Gain scores between 0.14 and 0.21, with

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an average of 0.1651 (SD = 0.01763). According to the N-Gain classification, the experimental class was categorized as having a medium improvement, whereas the control class was classified in the low category.

The average difference in N-Gain between the two groups was 0.3181, indicating that students in the experimental class experienced greater improvement in critical thinking skills than those in the control class. These findings suggest that interactive IPAS multimedia was more effective than conventional learning in enhancing students' critical thinking abilities.

Science Literacy

1. Pretest

The descriptive statistics showed that the experimental class obtained science literacy pretest scores ranging from 42 to 55, with a mean of 49.08 (SD = 4.183). The control class obtained scores between 41 and 55, with a mean of 48.27 (SD = 4.230). The difference of only 0.81 points indicates that the initial science literacy abilities of the two groups were relatively similar.

The Independent Samples t-test yielded a t-value of 0.707 (df = 52) with a significance value of 0.482 ($p > 0.05$). Therefore, no statistically significant difference was found between the two groups prior to the intervention, indicating equivalent baseline science literacy.

2. Posttest

After the implementation of interactive multimedia learning, the experimental class obtained science literacy posttest scores ranging from 67 to 80, with a mean of 74.08 (SD = 4.183). In contrast, the control class achieved scores between 59 and 81, with a mean of 68.92 (SD = 6.403). The experimental class outperformed the control class by an average of 5.16 points.

The Independent Samples t-test demonstrated a statistically significant difference between the experimental and control groups ($t = 3.500$, $df = 52$, $p = 0.001$). These findings indicate that interactive IPAS multimedia significantly improved students' science literacy compared with conventional learning.

3. N-Gain Analysis

The N-Gain analysis revealed that the experimental class achieved scores ranging from 0.43 to 0.56, with a mean of 0.4945 (SD = 0.04177). Meanwhile, the control class obtained scores between 0.31 and 0.58, with a mean of 0.4060 (SD = 0.08085). Both groups were classified within the medium improvement category, although the experimental class demonstrated a higher average gain.

The mean difference in N-Gain between the two groups was 0.0885, indicating greater improvement in science literacy among students who learned through interactive multimedia. Although both instructional approaches enhanced science literacy, the interactive multimedia approach produced more favorable learning gains.

Summary of Findings

The results consistently demonstrate that the experimental and control groups had comparable initial abilities in both critical thinking skills and science literacy before the intervention. Following the implementation of interactive IPAS multimedia, the experimental group achieved significantly higher posttest scores than the control group for both variables.

The N-Gain analysis showed that the experimental group experienced greater learning improvement than the control group. The most substantial difference was observed in critical thinking skills, while science literacy also improved more in the experimental class despite both groups being categorized within the medium improvement level. Overall, these findings indicate that interactive IPAS multimedia was more effective than conventional instruction in improving fifth-grade students' critical thinking skills and science literacy.

Discussion

Effect of Interactive IPAS Multimedia on Students' Critical Thinking Skills

The findings demonstrate that interactive IPAS multimedia effectively improved students' critical thinking skills compared with conventional instruction. Although both groups had comparable initial abilities before the intervention, students who learned through interactive multimedia showed significantly greater improvement in posttest achievement and

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normalized gain. These findings indicate that the integration of multimedia into IPAS learning provides a more effective learning environment for developing higher-order thinking skills than conventional teacher-centered instruction.

The effectiveness of interactive multimedia can be explained by the Cognitive Theory of Multimedia Learning proposed by Mayer, which suggests that students learn more effectively when verbal and visual information are presented simultaneously through complementary channels (Ali et al., 2025; Nurseha, 2025). The integration of text, animations, images, videos, and interactive activities allows students to construct richer mental representations, facilitating concept understanding and deeper cognitive processing. Rather than passively receiving information, students actively observe scientific phenomena, analyze relationships among concepts, evaluate evidence, and formulate conclusions, all of which are essential components of critical thinking.

These findings are also consistent with the constructivist perspective, which views learning as an active process of knowledge construction. Interactive multimedia encourages students to explore learning materials independently, respond to questions, and receive immediate feedback, thereby promoting active engagement throughout the learning process. Such learning experiences provide greater opportunities for students to practice interpretation, analysis, evaluation, and reasoning than conventional instruction, where learning is generally dominated by teacher explanations.

The present findings support previous studies reporting that interactive multimedia enhances students' higher-order thinking skills. (Rahmadani & Taufina, 2020) found that problem-based interactive multimedia significantly improved elementary students' critical thinking. Similarly, (Ulviah, 2024) and (Oktariani et al., 2024) reported that multimedia integrating inquiry activities strengthened students' analytical and evaluative abilities during science learning. The consistency of these findings suggests that interactive multimedia creates meaningful learning experiences that facilitate active cognitive engagement.

Although the experimental group achieved greater improvement, the normalized gain remained within the medium category. This finding indicates that critical thinking is a complex cognitive competence requiring continuous practice rather than short-term intervention. Consequently, interactive multimedia should be integrated consistently with inquiry-based learning, classroom discussion, and problem-solving activities to maximize students' critical thinking development.

Effect of Interactive IPAS Multimedia on Students' Science Literacy

Interactive IPAS multimedia also demonstrated a positive effect on students' science literacy. Students in the experimental class achieved significantly better science literacy outcomes than those in the control class, indicating that multimedia-assisted instruction supports students' ability to understand scientific concepts and apply scientific knowledge in meaningful contexts.

Science literacy requires more than remembering scientific facts; it involves explaining scientific phenomena, interpreting evidence, and making decisions based on scientific reasoning (Chusni et al., 2018; Kristyowati & Purwanto, 2019). Interactive multimedia supports these competencies by presenting scientific concepts through multiple representations, including animations, simulations, videos, and contextual illustrations. Such representations help elementary school students understand abstract concepts more concretely and relate classroom learning to everyday experiences.

From a constructivist perspective, multimedia facilitates knowledge construction by enabling students to interact directly with learning resources and gradually develop conceptual understanding through exploration. Students actively connect prior knowledge with new information, observe scientific phenomena, and evaluate evidence before drawing conclusions. This learning process is consistent with Piaget's view that meaningful learning occurs through active interaction with the environment and continuous cognitive adaptation (Fitriya et al., 2025).

The findings are consistent with previous research demonstrating that interactive multimedia enhances science literacy. (Putri et al., 2024) reported improvements in students' scientific reasoning and evidence interpretation through digital interactive learning media. Similar findings were reported by (Hafis & Ngazizah, 2022) and (Azhari, 2024), who concluded that multimedia-supported learning strengthens conceptual understanding and promotes scientific reasoning. The agreement between the present study and previous research reinforces the potential of interactive multimedia to improve science literacy in elementary education.

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Although both groups demonstrated medium normalized gain scores, the experimental class consistently achieved greater improvement. This result suggests that conventional instruction can improve science literacy to some extent; however, interactive multimedia provides additional learning experiences that facilitate conceptual visualization, scientific inquiry, and student engagement, leading to better learning outcomes.

Pedagogical Implications

The findings have important implications for elementary IPAS instruction. Interactive multimedia should not be viewed merely as a technological supplement but as a pedagogical tool that promotes active learning, conceptual understanding, and higher-order thinking. Teachers are encouraged to integrate multimedia with inquiry-based learning, collaborative discussion, and problem-solving activities to maximize students' critical thinking and science literacy. Such an approach is highly relevant to the implementation of the Merdeka Curriculum, which emphasizes student-centered, contextual, and competency-based learning.

Research Limitations

This study has several limitations. First, the participants were limited to 54 fifth-grade students from a single elementary school, which may limit the generalizability of the findings. Second, the intervention was conducted over a relatively short instructional period; therefore, the long-term effects of interactive multimedia on students' critical thinking and science literacy could not be examined. Future studies are recommended to involve larger and more diverse samples, extend the intervention period, and investigate additional learning outcomes such as creativity, problem-solving ability, and learning motivation.

CONCLUSION

IPAS This study demonstrates that interactive IPAS multimedia is more effective than conventional instruction in improving elementary students' critical thinking skills and science literacy. Students who learned using interactive multimedia showed greater improvement in both competencies, indicating that multimedia-based learning provides a more engaging and meaningful learning experience that supports higher-order thinking and scientific understanding.

These findings suggest that integrating interactive multimedia into IPAS instruction can serve as an effective pedagogical strategy for implementing student-centered learning in accordance with the objectives of the Merdeka Curriculum. By combining visual, auditory, and interactive learning experiences, multimedia facilitates active participation, conceptual understanding, and the development of essential twenty-first-century competencies.

This study is limited by its relatively small sample size and implementation in a single elementary school over a short intervention period. Therefore, future research is recommended to involve larger and more diverse samples, extend the duration of the intervention, and examine the long-term effects of interactive multimedia on other learning outcomes, such as problem-solving skills, creativity, and learning motivation.

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