

AI-BASED INTERACTIVE MEDIA AND READING LITERACY AS DETERMINANTS OF IPAS LEARNING OUTCOMES: A STUDY OF STUDENTS AT SDN LESANPURO 3 MALANG

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ABSTRACT

This study was motivated by low learning outcomes in Integrated Natural and Social Sciences (IPAS) among fifth-grade students at SDN Lesanpuro 3 Malang, which is driven by reliance on static, conventional media and students' limited reading literacy skills. The objective of this research was to analyze the main effects of AI-assisted interactive learning media and reading literacy levels, as well as their interaction, on IPAS learning outcomes. A quantitative quasi-experimental approach featuring a 2 x 2 factorial design was used with a sample of 56 fifth-grade students. Data were analyzed using Two-Way ANOVA. The findings revealed a statistically significant difference in learning outcomes between the AI-assisted media group and the conventional media group ($p = 0.005$) (2). Reading literacy exerted a highly significant influence on academic achievement ($p = 0.000$), and A significant interaction was identified between AI-based media usage and reading literacy levels ($p = 0.002$). It is concluded that integrating AI-driven interactive media while strengthening foundational reading literacy creates an effective instructional synergy, demonstrating that educational technology is most effective when supported by adequate student literacy capacity.

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INTRODUCTION

Twenty-first-century educational paradigms place strong emphasis on cultivating critical thinking, digital competence, and autonomous learning among students. In Indonesia, this transformation is embodied within the Merdeka Curriculum, particularly through the Integrated Natural and Social Sciences (IPAS) subject at the primary school level. IPAS instruction is designed to foster inquiry-based reasoning and contextual conceptual understanding. Mastery of IPAS content during elementary education serves as a critical cognitive foundation for higher academic tiers.

The integration of Artificial Intelligence (AI) into learning environments provides substantial opportunities to personalize instructional delivery, offer real-time feedback, and enhance engagement through interactive media. Concurrently, reading literacy,

which encompasses textual comprehension, critical analysis, and information evaluation, acts as a fundamental determinant of academic performance. However, most prior investigations have evaluated AI media and reading literacy in isolation, leaving a gap in understanding how these two factors interactively influence science learning outcomes in primary education.

An empirical issue was observed at SDN Lesanpuro 3, Malang, where only 40% of fifth-grade students met the minimum mastery threshold. Classroom instruction relied heavily on static visual presentations, with minimal student engagement, leaving available digital tools underutilized. Furthermore, weak reading comprehension created obstacles when students were confronted with analytical, context-rich problem-solving tasks. The novelty of this research lies in its simultaneous examination and interaction analysis of AI-assisted interactive media and reading literacy in relation to elementary IPAS achievement. This study aims to provide theoretical insights and practical recommendations for optimizing AI-driven educational technology in primary schools.

Nevertheless, prior studies have largely examined these variables in isolation, leaving a notable gap in understanding their combined effects on elementary IPAS outcomes. This gap is empirically underscored at SDN Lesanpuro 3, where only 40% of 56 fifth-graders met the minimum mastery criterion (average score of 62.5 vs. the standard of 75). Instruction remains dependent on static slides and underutilizes available interactive displays due to teachers' time and skill constraints, while students' deficient reading comprehension impedes analytical problem-solving.

The novelty of this research lies in its simultaneous examination of AI-assisted interactive media and reading literacy in relation to IPAS learning outcomes. Accordingly, this study aims to analyze these combined influences, contributing theoretical insights to educational technology and literacy discourse, while offering practical guidance for optimizing technology-driven IPAS instruction.

RESEARCH METHOD

This quantitative study employed a 2 x 2 factorial quasi-experimental design. The sample consisted of 56 fifth-grade students at SDN Lesanpuro 3 Malang, selected via purposive sampling based on initial academic equivalence. Class V-A ($n = 28$) formed the experimental group instructed using AI-based interactive media, whereas Class V-B ($n = 28$) served as the control group receiving conventional static media. The moderating variable, reading literacy, was split into high and low categories based on the median score of an initial literacy assessment.

Data were collected using three primary instruments: a reading literacy test, a pretest, and a posttest for IPAS learning outcomes. All instruments underwent expert content validation and empirical field testing on a non-sample class. Item analysis confirmed that all test items were valid ($p < 0.05$), with high reliability indicated by a Cronbach's Alpha coefficient of 0.969. Statistical prerequisite testing included normality checks (Kolmogorov-Smirnov and Shapiro-Wilk) and homogeneity of variance checks (Levene's Test). Hypothesis testing was subsequently performed using Two-Way

Analysis of Variance (ANOVA) and regression analysis.

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RESULTS AND DISCUSSION

Prerequisite Test Results

Before hypothesis testing, normality and homogeneity tests were conducted on the regression residuals. The Kolmogorov–Smirnov test yielded a p-value of 0.200, and the Shapiro–Wilk test yielded a p-value of 0.178; both values exceeded the 0.05 threshold, indicating that the residuals were normally distributed (Table 1). Levene's Test of Equality of Error Variances yielded $F(3, 52) = 1.803$, $p = 0.158$ ($p > 0.05$), indicating that the variance of learning outcomes was homogeneous across groups. The prerequisite analysis confirmed that the significance values for the Kolmogorov–Smirnov test ($p = 0.200$) and the Shapiro-Wilk test ($p = 0.178$) both exceeded the 0.05 significance threshold, verifying that the residual data were normally distributed. Levene's Test yielded $F(3, 52) = 1.803$ ($p = 0.158$), confirming homogeneity of variance across experimental groups. Thus, the dataset satisfied all parametric statistical assumptions.

Table 1. Normality and Homogeneity Test Results

Test	Statistic	df	Sig.
Kolmogorov–Smirnov	0.100	56	0.200
Shapiro–Wilk	0.970	56	0.178
Levene's Test	$F = 1.803$	3, 52	0.158

Source: SPSS output, 2026.

Learning Outcomes

Table 2 presents the pretest, posttest, and gain-score data for the experimental class ($n = 28$), which received AI-assisted interactive learning media integrated with reading-literacy activities, and the control class ($n = 28$), which was taught using conventional media.

Table 2. Descriptive Statistics of Pretest, Posttest, and Gain Score

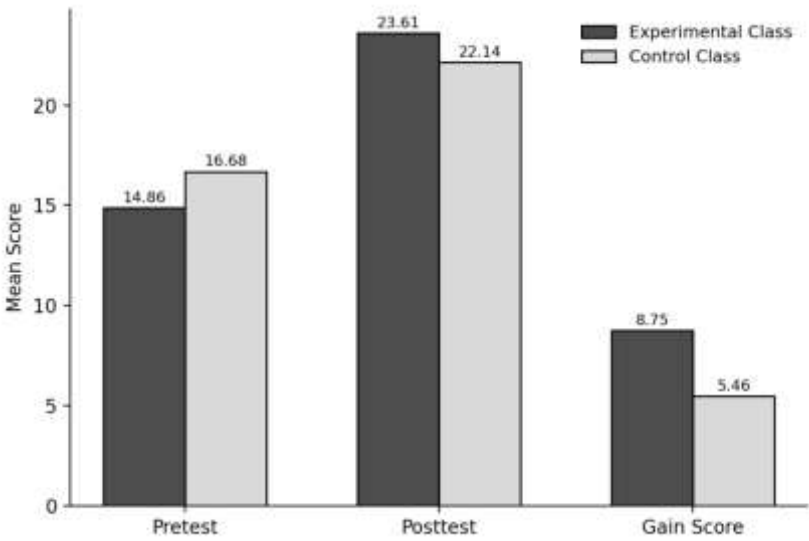
Group	Pretest Mean (Min–Max)	Posttest Mean (Min–Max)	Gain Score Mean
Experimental	14.86 (10–21)	23.61 (21–25)	8.75

Group	Pretest Mean (Min–Max)	Posttest Mean (Min–Max)	Gain Score Mean
Control	16.68 (11–21)	22.14 (20–24)	5.46

Source: Processed research data, 2026.

Although the control group started with a slightly higher baseline pretest score, the experimental group achieved a higher posttest average and a considerably larger gain score (8.75 vs. 5.46). Regarding the distribution of reading literacy, 64.29% of students in the experimental group were in the high-literacy category, compared with 46.43% in the control group.

Figure 1. Comparison of Mean Pretest, Posttest, and Gain Score between the Experimental and Control Classes



Source: Processed research data, 2026.

Reading Literacy

Table 3 summarizes the reading-literacy scores (maximum score 25) obtained by each group. In the experimental class, the mean literacy score was 16.39 (range 9–23), and 64.29% of students fell into the high-literacy category. In the control class, the mean literacy score was slightly higher, at 17.18 (range: 12–23); however, only 46.43% of students reached the high-literacy category, with most classified as low.

Table 3. Descriptive Statistics of Reading Literacy Scores

Group	Mean	Min	Max	High Category (%)
Experimental	16.39	9	23	64.29
Control	17.18	12	23	46.43

Source: Processed research data, 2026.

Hypothesis Testing

Difference in Learning Outcomes between AI-Assisted and Conventional Media

To evaluate the variation in Integrated Science (IPAS) learning outcomes, a one-way Analysis of Variance (ANOVA) was executed. As outlined in Table 4, the statistical test yielded a significant difference between students exposed to AI-assisted interactive media and those instructed using conventional media ($F(1, 54) = 15.302, p < 0.001$). Consequently, the null hypothesis (H_0) was rejected in favor of the alternative hypothesis (H_1). These findings demonstrate that the implementation of AI-integrated media leads to distinctly different academic performance compared to traditional instructional methods.

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Table 4. One-Way ANOVA Test Results

Source	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	142.131	1	142.131	15.302	.000
Within Groups	501.583	54	9.289	–	–
Total	643.714	55	–	–	–

Source: SPSS output, 2026.

Difference in Learning Outcomes between High- and Low-Literacy Groups

The two-way ANOVA results (Table 5) show that reading literacy had a significant effect on IPAS learning outcomes, $F(1, 54) = 27.707, p = 0.000$ ($p < 0.05$). H_0 was rejected, and H_1 was accepted, confirming a significant difference in learning outcomes between students with high and low reading literacy levels.

Table 5. Tests of Between-Subjects Effects (Two-Way ANOVA)

Source	Type III SS	df	Mean Square	F	Sig.
Corrected Model	218.287	1	218.287	27.707	.000
Intercept	2526.501	1	2526.501	320.692	.000
Literacy	218.287	1	218.287	27.707	.000
Error	425.427	54	7.878	–	–
Total	3444.000	56	–	–	–
Corrected Total	643.714	55	–	–	–

Note: $R^2 = .339$ (Adjusted $R^2 = .327$). Source: SPSS output, 2026.

Interaction between AI-Assisted Media and Reading Literacy

The regression model (Table 6) yielded $R = 0.651$ and $R^2 = 0.423$, indicating that AI-assisted media and reading literacy jointly accounted for 42.3% of the variance in IPAS learning outcomes. The Adjusted R^2 of 0.402 confirms that the model retained moderately strong explanatory power after adjusting for the number of predictors. The coefficient of determination indicates that the investigated variables account for a portion of the variance in learning outcomes, while the remaining 57.7% is influenced by other unmeasured factors. These residual variations may stem from external or internal factors, such as student motivation, prior knowledge, pedagogical strategies, or the learning environment, that were not directly evaluated in the current statistical model. The coefficient of determination indicates that the investigated variables account for a portion of the variance in learning outcomes, while the remaining 57.7% is influenced by other unmeasured factors. These residual variations may stem from external or internal factors, such as student motivation, prior knowledge, pedagogical strategies, or the learning environment, that were not directly evaluated in the current statistical model.

Table 6. Model Summary

Model	R	R Square	Adjusted R-Square	Std. Error of Estimate
1	.651	.423	.402	2.646

Predictors: (Constant), Literacy, Learning Media. Source: SPSS output, 2026.

The regression coefficients (Table 7) show that both predictors contributed significantly to the model ($p < 0.05$ for both), indicating that the interaction between AI-assisted media use and reading literacy significantly affected students' IPAS learning outcomes. H_0 was rejected, and H_1 was accepted.

Table 7. Regression Coefficients

Model	B	Std. Error	Beta	t	Sig.
(Constant)	14.733	1.290	—	11.419	.000
Learning Media	-2.141	.769	-.308	-2.783	.007
Literacy	-3.276	.759	-.478	-4.315	.000

Dependent variable: Learning Outcomes. Source: SPSS output, 2026.

As reported in Table 7, the negative signs of the regression coefficients for "Learning Media" and "Literacy" stem directly from the binary coding scheme used during data transformation. The target treatment group (AI-assisted learning) and high-literacy level were designated as the baseline reference category (coded as 1). Thus, while the mathematical sign appears negative due to the direction of comparison, the empirical interpretation remains consistent with a positive impact on student learning outcomes.

Discussion

Effect of AI-Assisted Interactive Media on Learning Outcomes

The significant improvement observed in the experimental class supports constructivist learning theory, in which knowledge is actively built through learners' own experience. It is consistent with Mayer's (2021) Cognitive Theory of Multimedia Learning, which holds that combining text, images, animation, and audio reduces cognitive load and facilitates comprehension of abstract concepts. Several mechanisms plausibly explain this effect: AI-assisted media sustained students' attention through combined visual-verbal elements, increased learning motivation by offering an interactive and personalized experience (Amalia & Kurniawan, 2023), and provided immediate feedback, allowing students to correct misconceptions in real time (Zawacki et al., 2019). These findings align with prior studies on AI-based tools in elementary science instruction (Simamora et al., 2025; Kurniawan et al., 2024), reinforcing that AI-assisted media is most effective when it complements, rather than replaces, the teacher's pedagogical role.

Effect of Reading Literacy on Learning Outcomes

Reading literacy also had a significant effect on learning outcomes, consistent with the view that reading comprehension is an active process of constructing meaning from text (Snow, 2018) and with earlier findings linking literacy to academic achievement (Pratiwi & Ramadhani, 2023). Because IPAS content is largely delivered through informational text, tables, and contextual narratives, students with stronger comprehension, vocabulary, and critical-thinking skills were better able to extract key ideas, connect new information to prior knowledge, and apply it to problem-solving. The smaller proportion of high-literacy students in the control class corresponds with its comparatively smaller gain score, further supporting the role of literacy in learning.

Interaction between AI-Assisted Media and Reading Literacy

The significant interaction effect indicates that AI-assisted media and reading literacy do not operate independently but reinforce one another. AI-assisted media supplies interactive, visually rich content and adaptive feedback, while reading literacy enables students to interpret and internalize that content; together they support deeper knowledge construction than either factor alone (Mayer, 2021). This finding is consistent with the caution raised by Holmes, Bialik, and Fadel (2019) that AI technology does not automatically improve learning outcomes—its effectiveness depends on how well it is integrated with students' capacity to process the information it provides. In practice, this suggests that maximizing the benefits of AI-assisted media in elementary IPAS instruction requires parallel efforts to strengthen students' reading and literacy skills.

CONCLUSION

This study confirms that both AI-based interactive learning media and reading literacy levels, independently and interactively, exert a significant effect on elementary students' IPAS achievement. Integrating advanced technological tools like AI does not substitute for core literacy competencies; rather, its instructional benefits are maximized when supported by adequate reading comprehension. In practice, educational institutions are encouraged to integrate digital media initiatives with structured reading literacy programs. Key limitations include the single-school setting and a brief intervention duration. Future research should expand sample sizes across diverse schools and examine additional moderating variables such as student motivation or critical thinking skills. Theoretically, these findings enrich educational technology scholarship by emphasizing the synergy between media design and learner characteristics. In practice, they suggest the simultaneous strengthening of literacy alongside AI utilization and encourage school policies to enhance digital infrastructure, teacher training, and sustainable literacy programs. Limitations include a single-school scope, a small sample (56 students), and a brief treatment duration. Future studies are advised to expand samples across schools, employ longitudinal designs, and examine other moderators such as motivation, critical thinking, or digital literacy. Developing AI media specifically tailored to low-literacy students also represents a promising avenue for further investigation.

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