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The Impact of Interactive Flat Panel (IFP) and Digital Quizzes as Predictors of Student Learning Outcomes in Mathematics Education

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Abstract

This study aims to provide empirical evidence on impacts resulting from the simultaneous use of interactive whiteboards and digital quizzes as determining factors in student learning outcomes in mathematics education. This study investigated whether the combined use of Interactive Flat Panels (IFP) and digital quizzes could predict students' mathematics learning outcomes. A quantitative correlational survey was conducted involving all 20 eighth-grade students at SMP Muhammadiyah 5 Surakarta using a saturated sampling technique. The study gathered data from Likert-scale questionnaires and students' academic records, which were subsequently analyzed through multiple linear regression. The analysis revealed contrasting findings between the two instructional technologies. The use of IFP demonstrated a significant negative association with students' learning outcomes, whereas digital quizzes showed no statistically significant contribution. When both variables were examined simultaneously, neither technology combination significantly predicted mathematics achievement. These findings suggest that simply introducing digital classroom technologies is insufficient to improve learning outcomes. The results indicate that technology is more likely to support mathematics achievement when its implementation is integrated with well-designed pedagogical practices that actively engage students and minimize unnecessary cognitive demands.

Keywords: *Interactive Flat Panel,* Digital Quiz, Mathematics Learning Outcomes, Multiple Linear Regression.

1. Introduction

Technology integration into mathematics education is increasingly recognized as important because mathematical concepts often require visualization, exploration, and interaction that cannot

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always be achieved through conventional methods. Recent studies show that digital technology in education has a meaningful impact only when it is truly integrated with learning strategies, not merely as an additional tool in the classroom; access to technology alone does not automatically lead to better learning outcomes (Tamarin & Prastowo, 2024). Mathematics media studies in national journals also show that interactive devices can help students understand concepts more concretely and are suitable for use in learning, as the visual features of these media effectively capture students' attention and facilitate comprehension (Ningsih et al., 2023; Yolanda & Laia, 2023). Therefore, the next issue is no longer just about the availability of technology, but how that technology is transformed into an active and meaningful learning experience, leading us to the challenges of its implementation in the classroom.

The availability of digital facilities in schools does not necessarily guarantee an automatic improvement in mathematics learning outcomes without proper pedagogical integration. Technology infrastructure is effective only when used to stimulate participation, collaboration, and targeted cognitive activities (Drijvers et al., 2021). The use of gamified interactive assessment tools can empirically enhance students' motivation, engagement, and academic achievement, although conventional challenges such as monotonous teaching approaches still often dominate the classroom (Kalogiannakis et al., 2021). This condition concludes that the core issue in mathematics education today is not the lack of hardware devices but rather the capacity of educators to integrate technology comprehensively. This further shifts the research focus toward optimizing the Interactive Flat Panel as the primary interaction tool in the classroom.

Interactive Flat Panel has strong potential to become a center for more visual, collaborative, and responsive mathematics learning. Research on smart board media for mathematics shows that interactive board media can meet the criteria of validity and practicality for classroom use, making it a suitable learning aid (Wahyudi et al., 2022). This feasibility is further reinforced by its ability to help teachers present material in a more engaging, structured, and interactive way, effectively encouraging students' attention and engagement during the learning process (Kühl & Wohninsland, 2022). These findings strengthen the idea that interactive flat panel is not just a one-way presentation tool but an interactive learning space where students can see, manipulate, and discuss mathematical concepts directly. From this point, the next focus shifts to the urgency of utilizing digital quizzes as evaluation instruments that serve as logical counterparts.

On the other hand, digital quizzes like Quizizz serve as formative assessments that make evaluation faster and more engaging and encourage student involvement. In the study by Zainuddin et al. (2020), The use of Quizizz media showed an increase in motivation and learning activity among mathematics students, while another study on Zep Quiz demonstrated a significant difference in mathematics learning outcomes with a very large effect size in the experimental class (Rahayu et al., 2025). When Quizizz was proven to influence elementary school students' mathematics learning outcomes in online learning (Shofiyah & Anwar, 2024). Therefore, digital quizzes are not

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just testing tools but part of the learning process, providing immediate feedback and reinforcing students' understanding, making them suitable for integration with IFP into a single learning model.

Although Interactive Flat Panel and digital quizzes have each demonstrated promising benefits in mathematics education, most academic literature still tests them separately. Studies on interactive media are generally dominated by development research focused on validity and practicality testing (Drijvers et al., 2021; Prasetya et al., 2020). Meanwhile, research on digital game-based assessment instruments tends to focus on single experimental designs to measure partial impacts on motivation, activity, or learning outcomes (Coelho et al., 2025; Ninaus et al., 2023; Zainuddin et al., 2020). This separation in research focus creates a significant gap in the literature, given that the presentation of visual materials and formative assessment should be integrated into a real classroom ecosystem (Kalogiannakis et al., 2021). As a result, empirical evidence modeling the interaction between these two instruments as predictors of learning outcomes remains very limited, especially when using inferential statistical approaches.

Theoretically, the integration of visual-manipulative representations via Interactive Flat Panel and immediate formative feedback from digital quizzes creates a synergistic learning ecosystem that optimizes students' cognitive load (Siller & Ahmad, 2024). This specific interaction not only facilitates concrete mathematical understanding but also actively stimulates the continuous cognitive engagement necessary to predict improved learning outcomes (Walter, 2024). Based on this theoretical synergy and the gaps in the literature that have been identified, this research aims to empirically demonstrate the measure to whom the simultaneous use interactive whiteboard and digital quizzes can serve as predictors of student learning outcomes in mathematics education.

2. Methods

This quantitative study utilized a correlation survey method and multiple linear regression analysis. The quantitative approach was chosen because this study focuses on testing objective theories by measuring the relationships between variables—namely, the use of Interactive Flat Panel and digital quizzes—and mathematics learning outcomes, using numerical data that is then analyzed statistically, an inferential approach frequently utilized to predict and model mathematics learning outcomes based on specific variables (Creswell & Creswell, 2018; Nugroho & Attin Warmi, 2022). The study involved students who had participated in mathematics lessons assisted by digital instruments. The research sample consisted of 20 students at SMP Muhammadiyah 5 Surakarta. The sampling was conducted by applying the saturation sampling technique, in which every member of the sample population was included in the study; this technique is typically used when the population is relatively small—that is, fewer than 30 people (Sugiyono, 2019).

There are the two independent variables in this study: the use of interactive flat-panel displays (X1) and digital quizzes (X2); and the dependent variable: student achievement in Math (Y). Operationally, the use of interactive flat panel is defined by the intensity and quality of the

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interactive screen's utilization during lessons. This is measured through aspects such as the clarity of visual presentations, interactivity, ease of understanding concepts, and the ability to stimulate student focus and engagement (Prasetya et al., 2020). Meanwhile, the use of digital quizzes is defined as the effectiveness of using evaluation media, including indicators such as motivation to learn, student engagement, ease of application, speed of feedback, and evaluation effectiveness (Zainuddin et al., 2020). Specifically, mathematics learning outcomes are measured objectively by recording students' scores on structured assignments.

The data collection methods used in this study relied on scaled questionnaires and academic documentation (Sugiyono, 2019). The questionnaire is used to quantify students' perceptions of the variables of Interactive Flat Panel utilization and digital quizzes, with each variable measured using 10 statement items. All of the statements were evaluated based on a five-point Likert scale ranging from Strongly Agree (5), Agree (4), Neutral (3), Disagree (2), and Strongly Disagree (1). Meanwhile, dependent variable is measured by documenting students' math assignment score recaps.

Prior to data collection, the research instrument has been examined to determine its validity and reliability. Item validities were assessed by Pearson's product-moment correlation, in which an item is considered valid if its correlation with the total score is statistically significant at the 5% significance level (Sig. < 0.05). Reliability was measured by Cronbach's Alpha, when a coefficient of more then 0.70 shows acceptable consistency (Muhammad et al., 2025; Utami et al., 2025). These processes were carried out to ensure that the instrument met the necessary measurement criteria before being used for data collection.

Data analysis began with descriptive statistics to describe the characteristics of observed data using their minimum, maximum, mean, and standard deviation. Before performing the regression analysis, classical assumption checks were carried out to confirm that the data met the conditions for multiple linear regression. Multiple linear regression is then used as a tool to examine the effects of the Interactive Flat Panel and digital quizzes on students' mathematics learning outcomes, which are measured using objective test scores. (Hasanah & Sulistiyo, 2021).

We tested the hypotheses using a t-test to find out how significant each independent variable's effect on students' math learning outcomes was on its own, and an F-test to assess the significance of the combined effect of both independent variables. Additionally, the determination coefficient (R^2) was used to assess the percent of variation in students' mathematics learning outcomes that can be attributed to the Interactive Flat Panel and digital quizzes. All statistical calculations in this study were performed at a 5% significance level using IBM SPSS Statistics software.

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3. Result and Discussion

Prior to further analysis, the validity and reliability of the Interactive Flat Panel (X1) instrument were tested to ensure the suitability of the research instrument. Validity was measured using Pearson's product-moment correlation; the items were considered valid if the two-tailed significance values were less than 0.05. The validity tests showed that all ten items of variable X1 had significance values ranging from 0.000 to 0.006, meaning that every item met the criteria for validity. The Pearson correlation coefficients with the total score ranged from 0.594 to 0.845. Detailed validity test results are presented in Table 1.

Table 1. *Results of the Validity Test for the Interactive Flat Panel Variable Instrument (X1)*
Correlations

		X1_1	X1_2	X1_3	X1_4	X1_5	X1_6	X1_7	X1_8	X1_9	X1_10	X1_total
X1_1	Pearson Correlation	1	,370	,414	,605**	,268	,550*	,513*	,306	,764**	,018	,631**
	Sig. (2-tailed)		,108	,069	,005	,254	,012	,021	,190	,000	,940	,003
	N	20	20	20	20	20	20	20	20	20	20	20
X1_2	Pearson Correlation	,370	1	,281	,756**	,732**	,331	,579**	,536*	,524*	,579**	,780**
	Sig. (2-tailed)	,108		,230	,000	,000	,155	,007	,015	,018	,007	,000
	N	20	20	20	20	20	20	20	20	20	20	20
X1_3	Pearson Correlation	,414	,281	1	,327	,467*	,686**	,554*	,361	,533*	,070	,594**
	Sig. (2-tailed)	,069	,230		,159	,038	,001	,011	,118	,016	,769	,006
	N	20	20	20	20	20	20	20	20	20	20	20
X1_4	Pearson Correlation	,605**	,756**	,327	1	,630**	,385	,515*	,371	,697**	,521*	,793**
	Sig. (2-tailed)	,005	,000	,159		,003	,094	,020	,107	,001	,018	,000
	N	20	20	20	20	20	20	20	20	20	20	20
X1_5	Pearson Correlation	,268	,732**	,467*	,630**	1	,435	,531*	,784**	,606**	,606**	,830**
	Sig. (2-tailed)	,254	,000	,038	,003		,055	,016	,000	,005	,005	,000
	N	20	20	20	20	20	20	20	20	20	20	20

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X1_6	Pearson Correlation	,550*	,331	,686**	,385	,435	1	,709**	,374	,679**	,220	,699**
	Sig. (2-tailed)	,012	,155	,001	,094	,055		,000	,104	,001	,350	,001
	N	20	20	20	20	20	20	20	20	20	20	20
X1_7	Pearson Correlation	,513*	,579**	,554*	,515*	,531*	,709**	1	,658**	,606**	,459*	,822**
	Sig. (2-tailed)	,021	,007	,011	,020	,016	,000		,002	,005	,042	,000
	N	20	20	20	20	20	20	20	20	20	20	20
X1_8	Pearson Correlation	,306	,536*	,361	,371	,784**	,374	,658**	1	,597**	,550*	,766**
	Sig. (2-tailed)	,190	,015	,118	,107	,000	,104	,002		,005	,012	,000
	N	20	20	20	20	20	20	20	20	20	20	20
X1_9	Pearson Correlation	,764**	,524*	,533*	,697**	,606**	,679**	,606**	,597**	1	,299	,845**
	Sig. (2-tailed)	,000	,018	,016	,001	,005	,001	,005	,005		,200	,000
	N	20	20	20	20	20	20	20	20	20	20	20
X1_10	Pearson Correlation	,018	,579**	,070	,521*	,606**	,220	,459*	,550*	,299	1	,623**
	Sig. (2-tailed)	,940	,007	,769	,018	,005	,350	,042	,012	,200		,003
	N	20	20	20	20	20	20	20	20	20	20	20
X1_total	Pearson Correlation	,631**	,780**	,594**	,793**	,830**	,699**	,822**	,766**	,845**	,623**	1
	Sig. (2-tailed)	,003	,000	,006	,000	,000	,001	,000	,000	,000	,003	
	N	20	20	20	20	20	20	20	20	20	20	20

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

The reliability test was then conducted by applying Cronbach's Alpha. The instruments were deemed reliable if their values exceeded 0.70. The test results for the ten items of variable X1 showed a Cronbach's Alpha value of 0.906. As this value exceeds the established criteria, the

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instruments for variable X1 are considered reliable and possess sufficient internal consistency for use in this study. The results of the reliability test for variable X1 are presented in Table 2.

Table 2. *Reliability Test Results for the Interactive Flat Panel Variable Instrument (X1)*

Reliability Statistics

Cronbach's Alpha	N of Items
,906	10

Furthermore, a validity test was conducted on the Digital Quiz (X2) variable instrument, which consists of 10 items. Following the implementation of the Pearson Product-Moment correlation test, it was determined that nine items satisfied the validity criteria, as their significance value (Sig., 2-tailed) was found to be less than 0.05. Conversely, item X2_2 exhibited a significance value of 0.062, thereby falling short of the established validity criteria. The total items correlation coefficients for the items that were deemed valid ranged from 0.606 to 0.911. Thus, nine items in variable X2 were considered valid, and one item—X2_2—was considered invalid. The results of the validity test for the Digital Quiz were presented in the Table 3.

Table 3. *Validity Test Results for the Digital Quiz Variable (X2)*

Correlations

		X2_1	X2_2	X2_3	X2_4	X2_5	X2_6	X2_7	X2_8	X2_9	X2_10	X2_total
X2_1	Pearson Correlation	1	,257	,561*	,511*	,213	,413	,321	,512*	,361	,434	,610**
	Sig. (2-tailed)		,274	,010	,021	,367	,071	,167	,021	,118	,056	,004
	N	20	20	20	20	20	20	20	20	20	20	20
X2_2	Pearson Correlation	,257	1	-,023	,440	,367	,356	,374	,066	,237	,017	,425
	Sig. (2-tailed)	,274		,923	,052	,111	,124	,104	,782	,313	,944	,062
	N	20	20	20	20	20	20	20	20	20	20	20
X2_3	Pearson Correlation	,561*	-,023	1	,693**	,417	,762**	,475*	,594**	,713**	,778**	,798**
	Sig. (2-tailed)	,010	,923		,001	,067	,000	,035	,006	,000	,000	,000
	N	20	20	20	20	20	20	20	20	20	20	20
X2_4	Pearson Correlation	,511*	,440	,693**	1	,730**	,707**	,757**	,548*	,787**	,607**	,911**
	Sig. (2-tailed)	,021	,052	,001		,000	,000	,000	,012	,000	,005	,000
	N	20	20	20	20	20	20	20	20	20	20	20

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X2_5	Pearson Correlation	,213	,367	,417	,730**	1	,590**	,689**	,366	,609**	,437	,712**
	Sig. (2-tailed)	,367	,111	,067	,000		,006	,001	,113	,004	,054	,000
	N	20	20	20	20	20	20	20	20	20	20	20
X2_6	Pearson Correlation	,413	,356	,762**	,707**	,590**	1	,681**	,310	,795**	,624**	,841**
	Sig. (2-tailed)	,071	,124	,000	,000	,006		,001	,183	,000	,003	,000
	N	20	20	20	20	20	20	20	20	20	20	20
X2_7	Pearson Correlation	,321	,374	,475*	,757**	,689**	,681**	1	,459*	,779**	,631**	,834**
	Sig. (2-tailed)	,167	,104	,035	,000	,001	,001		,042	,000	,003	,000
	N	20	20	20	20	20	20	20	20	20	20	20
X2_8	Pearson Correlation	,512*	,066	,594**	,548*	,366	,310	,459*	1	,434	,445*	,606**
	Sig. (2-tailed)	,021	,782	,006	,012	,113	,183	,042		,056	,049	,005
	N	20	20	20	20	20	20	20	20	20	20	20
X2_9	Pearson Correlation	,361	,237	,713**	,787**	,609**	,795**	,779**	,434	1	,778**	,888**
	Sig. (2-tailed)	,118	,313	,000	,000	,004	,000	,000	,056		,000	,000
	N	20	20	20	20	20	20	20	20	20	20	20
X2_10	Pearson Correlation	,434	,017	,778**	,607**	,437	,624**	,631**	,445*	,778**	1	,792**
	Sig. (2-tailed)	,056	,944	,000	,005	,054	,003	,003	,049	,000		,000
	N	20	20	20	20	20	20	20	20	20	20	20
X2_total	Pearson Correlation	,610**	,425	,798**	,911**	,712**	,841**	,834**	,606**	,888**	,792**	1
	Sig. (2-tailed)	,004	,062	,000	,000	,000	,000	,000	,005	,000	,000	
	N	20	20	20	20	20	20	20	20	20	20	20

*. Correlation is significant at the 0.05 level (2-tailed).
**. Correlation is significant at the 0.01 level (2-tailed).

Once the invalid items were omitted, a reliability test was applied to the nine remaining items thatmet the validity criteria. The results of the test showed a Cronbach's Alpha score of 0.920 across all nine. This value is greater than the criterion threshold of 0.70; therefore, the Digital Quiz (X2) variable instrument is deemed reliable. These results reveal that the nine items used possess good internal consistency and can be accepted to be used in this research. The results of the reliability test for X2 are presented in Table 4.

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Table 4. *The results of the reliability test for the Digital Quiz (X2)*

Reliability Statistics

Cronbach's Alpha	N of Items
,920	9

3.1 Partial Significance Test (t-test) and Regression Equation Modeling

The effect of each digital technology platform was evaluated separately or using a partially significant test (t-test) to analyze the contribution and direction of each platform's effect on learning outcomes. A regression parameter summary is provided in the "Coefficients" table.

Table 5. *Partial Significance Test Results (Coefficients).*
Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	101,383	7,358		13,779	,000
	IFP	-,797	,345	-,937	-2,311	,034
	Quiz Digital	,461	,307	,608	1,501	,152

a. Dependent Variable: Hasil Belajar

Based on the data matrix in the table, the formed multiple linear regression equation modeling is as follows:

$$Y = 101.383 - 0.797\,X1 + 0.461\,X2 \qquad (1)$$

Based on the equation and the output in the table, several crucial findings can be elaborated:
Constant Value (a): The constant indicates a value of 101.383. This suggests that if there is no intervention in the use of IFP or Digital Quizzes (where X1 and X2 are zero), the basic projected average math learning outcome for students remains at 101.383.

Effect of Interactive Flat Panel (X1): The regression coefficient for the intensity of Interactive Flat Panel use is negative at -0.797, with a t-value of -2.311 and a significance probability (Sig.) of 0.034. Since the significance value is less than the 5% significance level (0.034 < 0.05), the null hypothesis is declined. This proves that there is a statistically significant partial effect, but with a negative causal direction. Practically, each 1-unit increase in Interactive Flat Panel utilization intensity is projected to reduce math achievement scores by 0.797 units.

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These findings reveals an important empirical reality in the classroom. The decline in learning outcomes associated with increased use of interactive flat-panel displays could be explained from the viewpoint of Cognitive Load Theory. Math learning fundamentally requires active reasoning and problem-solving processes (Klepsch & Seufert, 2020). When Interactive Flat Panel is used predominantly as a visual presentation tool with high information density, without structured pedagogical integration, the device actually burdens students' working memory capacity (Kadir et al., 2021). Students tend to shift to passive observers of media features, leaving less space to manipulate concepts independently (Yunita, 2026). Although interactive panels provide rich visualizations (Patta, 2025), the dominance of one-way presentation fails to optimize substantial cognitive engagement (Kühl & Wohninsland, 2022). Ultimately, students' attention is more absorbed by the media interface rather than by constructing concrete mathematical reasoning (Ningsih et al., 2023).

Effect of Digital Quizzes (X2): The Digital Quiz variable shows a positive coefficient of 0.461, a t-value of 1.501, and a significance level of 0.152. Although the coefficient indicates a trend toward increasing scores, the significance value exceeding the 5% threshold (0.152 > 0.05) requires acceptance of the null hypothesis. It can be concluded that the use of Digital Quizzes, such as Quizizz, has not yet had a significant, comprehensive effect on students' academic achievement (Nirmalasari & Susanti, 2023). The digital quiz, often limited by timers and leaderboards, regularly urges students to respond rashly to questions in order to chase speed, which, in turn, compromises the accuracy and depth of analytical reasoning (Ninaus et al., 2023; Tamarin & Prastowo, 2024). Gamified assessments have proven effective in motivating initial competitive engagement (Coelho et al., 2025; Shofiyah & Anwar, 2024), but this dynamic does not automatically translate into mature, structured problem-solving that requires rationalization.

3.2 The Simultaneous Significance Test (F-test)

To assess the overall model feasibility (quality of fit) and to determine whether Interactive Flat Panel and Digital Quizzes jointly influence students' academic outcomes, the F-test parameters are analyzed using the total degrees of freedom. This summary of parameters is presented in Table 6.

Tabel 6. *Model Feasibility Test Results (ANOVA).*

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	104,613	2	52,306	3,118	,070[b]
	Residual	285,187	17	16,776		
	Total	389,800	19			

a. Dependent Variable: Hasil Belajar
b. Predictors: (Constant), Quiz Digital, IFP

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The ANOVA output shows an F-value of 3.118 and a Sig. of 0.070. Referring to the regression decision rule, because the significance value is above the standard error of 0.05 (0.070 > 0.05), the null hypothesis claiming a significant simultaneous effect must be declined. So, the combination of Interactive Flat Panel-based visualization instruments and a Digital Quiz is not yet strong enough to serve as a primary predictor of improved mathematics study results.

3.3 Coefficient of Determination Analysis (R Square)

Results of the determination coefficient calculation, which indicates the model's potential contribution, further confirm that the model's predictive ability remains limited. The detailed coefficient values are shown in Table 7.

Tabel 7. *Coefficient of Determination (Model Summary)*

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	,518[a]	,268	,182	4,096

a. Predictors: (Constant), Quiz Digital, IFP
b. Dependent Variable: Hasil Belajar

From the model results summary table, the R-square value is 0.268. This shows that the interaction between the use of Interactive Flat Panels and Digital Quizzes explains only 26.8% of the total variability in students' mathematics learning outcomes. There remains a dominant residual variance of 73.2%, indicating that students' learning outcomes are significantly influenced by external and internal variables that are outside the scope of this study (such as levels of math anxiety, independent learning, or teaching style).

The residual variance of 73.2% indicates that most of the variation remains unexplained by the model, thereby confirming that the effectiveness of technological infrastructure depends heavily on the implementation of appropriate pedagogical strategies (Naidoo, 2025). The success of cognitive transfer depends much more on educators' ability to design a participatory learning framework, such as the implementation of Problem-Based Learning approaches (Sagita & Ikashaum, 2023; Zou et al., 2026), guided cooperative models (Rahayu et al., 2025; Ratnasari et al., 2020), and realistic mathematics learning environments that encourage students to develop a concept through contextual skills and active discussion (Setyaningsih et al., 2019). Without a classroom ecosystem that promote collaboration and targeted cognitive activities, classroom digitalization merely changes the presentation format from conventional media to interactive screens but fails to meaningfully impact the essence of learning achievement (Reinhold et al., 2024; Simon et al., 2025; Wahyudi et al., 2022). This also aligns with students' vulnerability to digital

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intelligence automation, where dependence on instant media can reduce students' independence and mental resilience when solving essential mathematical procedures (Aljura & Retnawati, 2026; Khusna & Fadli, 2025).

4. Conclusion

The combination of Interactive Flat Panel instruments and digital quizzes has not significantly improved students' academic achievement collectively. Partially, digital quiz instruments proved not to have a significant effect on student academic outcomes. Conversely, an increase in the intensity or frequency of Interactive Flat Panel Device use actually resulted in a negative impact upon student mathematics achievement. This phenomenon underscores that intensive exposure to visual technology without the integration of participatory pedagogical design is prone to triggering excessive cognitive load, which disrupts the reasoning process. With digital media accounting for only 26.8% of the variability in learning outcomes, the essence of transforming mathematics education lies not solely in the availability of advanced hardware, but in the educator's capacity to craft instructional strategies centered on students' analytical activities and problem-solving.

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