



Smartphone Use in Mathematics Learning: Effects on Students' Mathematical Understanding and Learning Motivation

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Abstract

Purpose: This study examines the relationship between smartphone use and two key learning outcomes in secondary mathematics education: students' mathematical understanding and mathematics learning motivation. The increasing availability of mobile technologies has created new opportunities for integrating digital resources into classroom instruction. However, the educational impact of smartphones depends largely on how they are pedagogically implemented. This research therefore investigates whether guided smartphone use during mathematics learning is associated with improvements in students' conceptual understanding and learning motivation. **Methodology:** A quantitative correlational design was employed involving 57 Grade X students from a public secondary school in Indonesia. Data were collected using a mathematical understanding test and a mathematics learning motivation questionnaire following one semester of smartphone-supported learning. Data analysis included descriptive statistics, normality and linearity testing, and simple linear regression analysis. **Findings:** The results indicate that smartphone integration is positively associated with students' mathematical understanding and learning motivation, although the magnitude of the explained variance is relatively modest. **Significance:** These findings suggest that smartphones can function as supportive learning tools when integrated through structured pedagogical activities that encourage conceptual exploration and collaborative discussion. The study contributes to the growing literature on mobile learning in mathematics education by highlighting the importance of teacher-guided smartphone integration in supporting both cognitive and motivational aspects of learning.

Keywords: Smartphone integration; Mobile learning; Mathematical understanding; Learning motivation; Mathematics education



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Introduction

The ability to develop a deep understanding of mathematical concepts, explain how these concepts are interconnected, and apply them flexibly, accurately, and efficiently in problem-solving is widely regarded as a fundamental mathematical competency (Ulpah & Insani, 2025). Mathematical understanding has long been recognized as a central goal of mathematics education (NCTM, 2000; Kilpatrick et al., 2001). More recent studies highlight that such understanding goes beyond mere procedural fluency, encompassing the ability to relate concepts to one another and apply them meaningfully in real-world contexts (Sudirman et al., 2026). For this reason, mathematical understanding continues to be positioned as a key objective of mathematics education, as it enables students to use knowledge meaningfully, tackle complex problems, and engage in critical thinking (NCTM, 2013; Garcia-Garcia, 2023). Students with strong conceptual understanding are more likely to internalize mathematical ideas, which in turn contributes positively to their overall learning outcomes.

However, mathematical understanding is conceptualized in multiple ways across contexts. The form of understanding pursued by mathematicians in research settings differs markedly from that expected in classroom instruction (Carter, 2024). Authentic understanding extends beyond the mere memorization of procedures or the execution of routine algorithms (Görgüt & Dede, 2022). Rather, it involves establishing meaningful connections among mathematical facts and concepts, integrating new knowledge with prior knowledge, and organizing these elements into a coherent and well-structured conceptual framework (Sierpinska, 2013).

In addition to conceptual understanding, students must possess adequate motivation to engage in learning mathematics. Learning motivation plays a critical role in fostering persistence, focus, and sustained engagement, thereby enhancing academic achievement and supporting lifelong learning (Gupta & Mili, 2017; Munawaroh et al., 2022). It also contributes to the development of effective study habits and goal-directed learning behaviors (Zakaria et al., 2020). Research in this area not only informs instructional practices but also provides a foundation for the design of broader educational programs and policies aimed at promoting personal development and overall well-being (Ishida & Sekiyama, 2024).

Despite its importance, many students continue to experience difficulties in developing strong conceptual understanding of mathematics (Fielding & Makar, 2022; Hussein & Csikos, 2023). Traditional classroom practices frequently emphasize procedural instruction and routine exercises rather than conceptual exploration (Ncube & Luneta, 2025). As a consequence, students may successfully perform algorithmic procedures yet struggle to interpret mathematical concepts or apply them in novel contexts (Lehmann, 2023). These challenges highlight the need for instructional approaches that promote deeper cognitive engagement in mathematics learning (Gradini et al., 2025).

In addition to conceptual understanding, students' motivation to learn mathematics represents another critical factor influencing learning outcomes (Wang & Kao, 2022; Wen & Dubé, 2022; Zhang et al., 2023). Motivation affects students' persistence, cognitive effort, and willingness to engage with challenging problems. Learners who demonstrate higher levels of motivation are more likely to persevere when solving complex tasks and to develop positive attitudes toward mathematics (Wakhata et al., 2024). Conversely, low motivation often results in disengagement and reduced learning achievement (Russo et al., 2026).

To achieve the dual objectives of fostering mathematical understanding and enhancing learning motivation, the adoption of innovative instructional approaches is imperative. The integration of technology in education offers a multitude of opportunities to enhance teaching and learning (Oumelaid et al., 2025). One promising avenue lies in the integration of smartphones as learning resources. Smartphones have evolved beyond their primary function as communication devices to become essential tools for accessing information, facilitating learning processes, and integrating seamlessly into everyday life (Ak, 2024). Their incorporation into educational contexts has not only transformed instructional

practices but also created new learning opportunities for students (Yildirim & Yilmaz, 2025).

In many educational settings, smartphones are widely accessible due to their relative affordability compared to other digital devices (Peteros et al., 2022). Although the potential adverse effects associated with smartphone use require careful regulation (Zhou et al., 2022), their pedagogical potential warrants systematic investigation. Teachers play a pivotal role in guiding students toward meaningful learning outcomes, particularly in developing robust conceptual understanding. The use of smartphones can support the integration of key elements of effective learning, including motivation, collaboration, and authentic learning experiences (Wijers et al., 2010). Within this context, the present study seeks to evaluate the use of smartphones as tools for assessing students' mathematical understanding and to propose an empirically grounded model to support such assessment. In doing so, it aims to make a substantive contribution to the advancement of research in mathematics education.

Literature Review

Mathematical understanding has been conceptualized both as a dynamic process of constructing meaning and as an outcome reflecting the attainment of such understanding (Cai & Ding, 2015). Within this framework, Skemp (1976) delineates three forms of understanding: instrumental, relational, and formal. Instrumental understanding refers to the ability to apply memorized rules or procedures to solve problems without comprehending the underlying rationale. In contrast, relational understanding involves the capacity to derive specific procedures from broader mathematical relationships, thereby emphasizing coherence and meaning. Formal understanding extends this capacity by enabling individuals to connect mathematical symbols and notations with relevant conceptual ideas and to integrate these into coherent chains of logical reasoning.

Furthermore, mathematical understanding encompasses a range of cognitive processes and outcomes, including the ability to recall learned knowledge, transfer it to novel contexts, and encode information effectively (Garegae, 2007). From a constructivist perspective, understanding is not merely the internalization of externally presented representations or instructional input, but rather the result of active individual construction (Schliemann, 2002). While philosophical discussions often emphasize understanding through explanatory proofs, it may also pertain to the comprehension of concepts, results, theories, or methods (Carter, 2024). Based on these perspectives, mathematical understanding can be defined as the ability to comprehend mathematical concepts and to establish meaningful connections among them, thereby enabling accurate computation and effective problem solving.

Indicators of Mathematical Understanding

In this study, the indicators are primarily adapted from the conceptual understanding framework proposed by Jihad and Haris (2010), which includes: (1) the ability to restate a learned concept; (2) the ability to classify objects according to their defining properties; (3) the ability to identify examples and non-examples of a concept; (4) the ability to represent concepts in various mathematical forms; (5) the ability to use, select, and implement appropriate procedures or operations; (6) the ability to apply concepts or algorithms in problem-solving contexts; and (7) the ability to formulate necessary and sufficient conditions of a concept.

Similarly, the NCTM (2000) outlines indicators of students' mathematical understanding reflected in their ability to: (1) identify concepts both verbally and in written form; (2) generate examples and counterexamples; (3) represent concepts using models, diagrams, and symbols; (4) translate between different forms of representation; (5) identify the defining properties and conditions of a concept; (6) recognize multiple meanings and interpretations of a concept; and (7) compare and distinguish among related concepts. Based on these theoretical perspectives, the indicators employed in this study are synthesized as follows: (1) the ability to restate a learned concept; (2) the ability to classify objects based

on their defining properties; (3) the ability to construct examples and non-examples; (4) the ability to translate between different forms of representation; and (5) the ability to select and apply appropriate procedures or operations.

Motivation in Mathematics Learning

Motivation is widely recognized as a critical determinant in the learning process, as it substantially influences the attainment of intended learning outcomes (In'am & Sutrisno, 2021). It is commonly conceptualized as an individual attribute, reflecting a learner's initial readiness to engage in learning as well as the affective dispositions experienced during and after the learning process (Kim & Kim, 2021). From a psychological perspective, learning motivation is regarded as a non-intellectual factor that plays a distinctive role in fostering enthusiasm, enjoyment, and sustained engagement in learning activities (Setiawan, 2016). In the context of mathematics education, motivation is particularly essential, as students with high levels of motivation tend to demonstrate persistence in completing tasks, resilience in overcoming difficulties, and sustained interest in problem-solving activities, especially those involving mathematical challenges (Hutajulu et al., 2019). Such students are driven by goal-oriented needs, including the desire to understand mathematical concepts and successfully solve problems (Bishara, 2016).

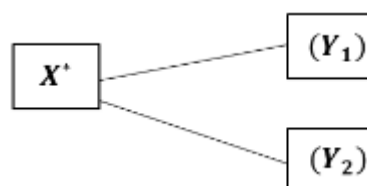
Based on these perspectives, motivation can be defined as an internal and external force that generates an individual's willingness to engage in specific activities. This motivation may originate intrinsically—from within the individual—or extrinsically—from external influences. The strength of this motivational drive substantially determines the quality of behavior exhibited across various contexts, including learning, professional activities, and everyday life.

According to Sardiman (2001), indicators of learning motivation include: (1) persistence in completing tasks; (2) resilience in facing difficulties without easily giving up; (3) interest in a wide range of problems; (4) a preference for working independently; (5) a tendency to become easily bored with routine tasks; and (6) the ability to defend one's opinions. In the present study, these indicators proposed by Sardiman (2001) are adopted as the operational framework for assessing students' motivation in mathematics learning.

Method

This study employed a quantitative approach with a correlational research design. Correlational research is a methodological approach aimed at identifying and analyzing relationships between two or more variables without experimental manipulation (Putri et al., 2025). Correlational research examines the relationships between two or more variables to determine if they are associated or correlated. This design does not imply causation but identifies patterns and strengths of associations (Curtis et al., 2016). This design was selected because the present study seeks to test hypotheses concerning the expected relationships among smartphone use, mathematical understanding, and learning motivation. The research design is illustrated in Figure 1.

Figure 1
Research Design



Notes:

X = use of smartphone

Y_1 = mathematical understanding ability

Y_2 = mathematics learning motivation

Participants

The population of this study comprised all Grade X science-track students (MIPA) at SMA Negeri 6 Karawang, totaling 133 students distributed across four classes, as presented in Table 1.

Table 1*Distribution of Grade X MIPA Students at SMA Negeri 6 Karawang*

No.	Class	Number of Students
1	X MIPA 1	33
2	X MIPA 2	33
3	X MIPA 3	33
4	X MIPA 4	34
Total		133

From this population, the sample size was determined using the Slovin formula. Subsequently, participants were selected through a simple random sampling technique to ensure equal representation. With a margin of error set at 10%, the resulting sample consisted of 57 students. These participants were proportionally distributed across the four classes, with approximately 14–15 students selected from each class.

Instruments

This study employed three primary instruments: (1) a learning achievement test administered following smartphone-assisted instruction, (2) a Mathematical Conceptual Understanding Test (KPM), and (3) a mathematics learning motivation questionnaire. The first instrument, the learning achievement test, was adapted from a standard mathematics textbook and designed as a semester final examination. It was developed collaboratively by a teaching team and consisted of 30 items, including 25 multiple-choice questions and 5 open-ended (essay) questions.

The second instrument assessed students' mathematical conceptual understanding (KPM) and comprised five items constructed based on key indicators of conceptual understanding: (1) the ability to restate a learned concept; (2) the ability to classify objects according to their defining properties; (3) the ability to generate examples and non-examples of a concept; (4) the ability to translate between different forms of representation; and (5) the ability to select and apply appropriate procedures or operations. The third instrument was a learning motivation questionnaire consisting of 20 statements, as outlined in Table 2. The questionnaire was designed to capture multiple dimensions of students' motivation in learning mathematics. Prior to administration, all test instruments were pilot-tested to establish their validity and reliability.

Table 2*Blueprint of the Mathematics Learning Motivation Questionnaire*

No.	Indicator	Item Numbers	Total
1	Persistence in completing tasks	6, 8, 19	3
2	Resilience in facing difficulties (not easily discouraged)	5, 9, 13, 21	4
3	Interest in various real-life problems	2, 7, 18	3

No.	Indicator	Item Numbers	Total
4	Preference for independent work	1, 17, 30	3
5	Tendency to become easily bored with routine tasks*	10*, 11*, 15*, 22*, 25*	5
6	Ability to defend one's opinion	4, 12	2
Total			20

Note: Items marked with an asterisk are negatively worded statements.*

Data Collection Procedure

The data collection process was conducted in two main stages. The first stage involved the implementation of mathematics instruction over one semester. Four classes of students were taught the topic of sequences and series. During this instructional process, students were required to bring and utilize smartphones as supplementary learning tools to access additional materials and references beyond textbooks, worksheets (LKS), and teacher explanations. This instructional approach was collaboratively implemented by the teaching team throughout the semester. At the end of the instructional period, students completed a semester final examination (UAS) to assess their learning outcomes. The second stage involved the administration of the Mathematical Conceptual Understanding (KPM) test, consisting of five items, which was conducted on a different day and administered only to the selected sample. Subsequently, on the same day, the mathematics learning motivation questionnaire was distributed to the participants to capture their motivational profiles.

Data Analysis Procedure

Data analysis was performed using *Statistical Product and Service Solutions (SPSS)* version 22 for Windows. The analytical procedure comprised several steps, beginning with the testing of prerequisite assumptions.

Assumption Testing

Parameter estimation in linear regression analysis requires that the residuals (errors) of the model follow a normal distribution. To verify this assumption, a normality test was conducted on the residuals. One commonly employed method for assessing data normality is the Kolmogorov–Smirnov test. The suitability of a model to the observed data is often not known a priori; therefore, model evaluation is typically focused on the analysis of residuals to ensure that underlying statistical assumptions are satisfied.

Normality Test

A normality test is conducted to determine whether the obtained data follow a normal distribution. In the context of regression analysis, the normality test specifically examines whether the residuals (errors) generated by the regression model are normally distributed. The normality test constitutes a fundamental component of the prerequisite tests for data analysis. This implies that prior to conducting statistical hypothesis testing using simple linear regression analysis, the data must first be examined to ensure that the assumption of normality is satisfied.

In this study, the normality test was performed using the Kolmogorov–Smirnov method, as the sample size was equal to or greater than 50 respondents. The test was conducted using SPSS version 22 for Windows. The decision criterion is based on the Asymp. Sig. (p-value): if the value exceeds 0.05, the data are considered to be normally distributed; conversely, if the value is less than or equal to 0.05, the data are not normally distributed.

The hypotheses for the normality test are formulated as follows:

H_0 : The population distribution is normal (residuals/errors are normally distributed).

H_1 : The population distribution is not normal (residuals/errors are not normally distributed).

The decision rules are as follows:

- If the significance value (Sig.) > 0.05 , H_0 is accepted, indicating that the regression model residuals are normally distributed.
- If the significance value (Sig.) ≤ 0.05 , H_0 is rejected, indicating that the regression model residuals are not normally distributed.

Linearity Test

The linearity test is conducted to determine whether there is a statistically significant linear relationship between two variables. A robust correlation is characterized by a linear association between the independent variable (X) and the dependent variable (Y). In many methodological references, the linearity test is regarded as a prerequisite assumption prior to performing simple linear regression analysis. In this study, the linearity test was performed using SPSS version 22 for Windows. The decision criterion is based on the significance value of linearity (Sig. Linearity). If the significance value exceeds 0.05, the relationship between the independent and dependent variables is considered linear. Conversely, if the value is less than or equal to 0.05, the relationship is deemed non-linear (Kadir, 2015). The hypotheses for the linearity test are formulated as follows:

H_0 : The regression data exhibit a linear relationship (the two variables are linearly related).

H_1 : The regression data do not exhibit a linear relationship (the two variables are not linearly related).

The decision rules are as follows:

If the significance value of linearity (Sig. Linearity) > 0.05 , H_0 is accepted.

If the significance value of linearity (Sig. Linearity) ≤ 0.05 , H_0 is rejected.

Hypothesis Testing

In general, simple linear regression analysis is employed to measure the magnitude of the effect of an independent variable (X) on a dependent variable (Y). In this study, simple linear regression was utilized to test the first and second hypotheses, specifically to examine the effect of the independent variable (X) on each dependent variable (Y) separately.

The regression analysis was conducted using SPSS version 22 for Windows. The decision criterion is based on the significance value (p-value). If the significance value is less than 0.05, the regression model is considered statistically significant, indicating the presence of a linear relationship between variables. Conversely, if the significance value is greater than or equal to 0.05, the model is not statistically significant. The hypotheses are formulated as follows:

H_0 : The regression model is not significant (the independent variable (X) does not have a positive effect on the dependent variable (Y)).

H_1 : The regression model is significant (the independent variable (X) has a positive effect on the dependent variable (Y)).

The decision rules are as follows:

If the significance value ≥ 0.05 , H_0 is accepted.

If the significance value < 0.05 , H_1 is accepted.

The procedural steps for hypothesis testing using simple linear regression analysis are as follows: (1) formulating the hypotheses; (2) determining the significance level ($\alpha = 0.05$); (3) conducting regression analysis using SPSS; (4) interpreting the significance value (p-value); and (5) drawing conclusions based on the established decision criteria.

Estimation of the Regression Equation

In general, the simple linear regression model is expressed as:

$$Y = a + \beta X$$

where Y denotes the dependent variable, X represents the independent variable, a is the constant (intercept), and β is the regression coefficient of the independent variable.

The values of the regression coefficients are obtained from the SPSS output, specifically from the

Coefficients table, by examining the calculated t-values and their corresponding significance levels (Sig.), in accordance with the hypothesis testing criteria described previously.

Linearity and Significance of the Regression Model

The evaluation of linearity and the statistical significance of the regression model is based on the ANOVA Table and ANOVA output in SPSS. *Hypotheses for the ANOVA Table (Linearity Test):*

$H_0: Y = a + \beta X$ (the regression is linear)

$H_1: Y \neq a + \beta X$ (the regression is not linear)

Decision criteria:

- If Sig. > 0.05, H_0 is accepted.
- If Sig. \leq 0.05, H_0 is rejected.

Particularly, the *Deviation from Linearity* row in the ANOVA Table is examined. If the significance value (Sig.) exceeds 0.05, H_0 is accepted, indicating that the relationship between X and Y is adequately represented by a linear model. *Hypotheses for ANOVA (Model Significance):*

$H_0: \beta = 0$ (the regression model is not significant)

$H_1: \beta \neq 0$ (the regression model is significant)

Decision criteria:

- If Sig. \geq 0.05, H_0 is accepted (the regression is not significant).
- If Sig. < 0.05, H_0 is rejected (the regression is significant).

The significance of the regression model is determined from the ANOVA table, specifically the *Regression* row, by examining the F-value and its associated significance level. A significance value below 0.05 indicates that the regression model is statistically significant.

Significance of the Effect of X on Y

The statistical hypotheses for testing the significance of the relationship between the independent variable (X) and the dependent variable (Y) are as follows:

$H_0: \rho = 0$ (no significant relationship/effect)

$H_1: \rho \neq 0$ (a significant relationship/effect exists)

Decision criteria:

- If Sig. \geq 0.05, H_0 is accepted.
- If Sig. < 0.05, H_0 is rejected.

The significance of the correlation coefficient between X and Y is obtained from the *Model Summary* table in the SPSS output. The correlation coefficient (r_{xy}) and the F-change statistic are considered. A significance value below 0.05 indicates that the relationship between X and Y is statistically significant. Furthermore, the coefficient of determination (R^2), as reported in the *Model Summary* table, is used to quantify the proportion of variance in the dependent variable (Y) that can be explained by the independent variable (X) in the simple linear regression model.

Results and Discussions

Based on the data obtained from the final mathematics examination (UAS) of Grade X MIPA students, the mean score representing variable X (smartphone use) was 76.46. This score exceeds the minimum mastery criterion (KKM) for mathematics, which is set at 75. Furthermore, the results of the mathematical understanding test, representing variable Y_1 , yielded a mean score of 26.04, which remains substantially below the maximum possible score of 50. In addition, the non-test data derived from the mathematics learning motivation questionnaire, representing variable Y_2 , indicated a mean score of 73.12, which is still below the maximum score of 100.

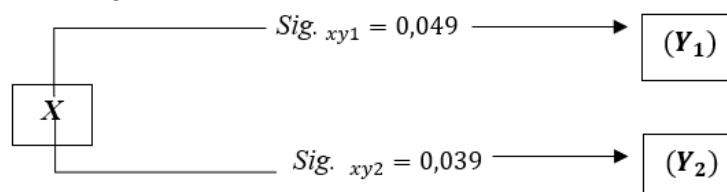
Subsequently, prerequisite analyses were conducted, including tests of normality and linearity for

the UAS mathematics scores (X), students' mathematical understanding test results (Y_1), and the motivation questionnaire data (Y_2). The results of the residual normality test for the relationship between X and Y_1 (XY_1) showed an Asymp. Sig. value of 0.065, which exceeds 0.05; therefore, H_0 is accepted, indicating that the residuals are normally distributed. Similarly, the residual normality test for the relationship between X and Y_2 (XY_2) produced an Asymp. Sig. value of 0.200 (> 0.05), confirming a normal distribution of residuals.

Regarding linearity, the test results for the relationship between X and Y_1 (XY_1) yielded a Sig. Linearity value of 0.526 (> 0.05), indicating a linear relationship between smartphone use and students' mathematical understanding. Likewise, the linearity test for the relationship between X and Y_2 (XY_2) produced a Sig. Linearity value of 0.983 (> 0.05), confirming a linear relationship between smartphone use and students' mathematics learning motivation. These findings demonstrate that all prerequisite assumptions for regression analysis are satisfied. The results of the hypothesis testing, conducted separately, indicate that smartphone use has a positive effect on both students' mathematical understanding and their motivation to learn mathematics. These findings are further illustrated in Figure 2.

Figure 2

Summary of Research Findings



Notes:

- X = smartphone use
- Y_1 = mathematical understanding ability
- Y_2 = mathematics learning motivation
- Sig. XY_1 = partial effect of X on Y_1
- Sig. XY_2 = partial effect of X on Y_2

There is a positive effect of smartphone use on senior high school students' mathematical understanding ability.

The relationship between smartphone use (X) and students' mathematical understanding (Y_1) was examined using simple linear regression analysis, as presented in Table 3.

Table 3

Results of Hypothesis Testing (Effect of X on Y_1)

Model		Coefficients ^a		Standardized Coefficients	T	Sig.
		Unstandardized Coefficients	Std. Error			
		B		Beta		
1	(Constant)	218.245	95.641		2.282	.026
	X	2.514	1.251	.262	2.010	.049

a. Dependent Variable: Y1

As presented in Table 3, the estimation results yielded $\alpha = 218.245$ and $\beta = 2.514$. Substituting these values into the regression equation produces the simple linear regression model: $\hat{Y} = 218.245 + 2.514X$. Prior to conducting the regression analysis, prerequisite tests—including normality and linearity—were performed. The normality test indicated an Asymp. Sig. value of 0.065, which exceeds the significance level of $\alpha = 0.05$, confirming that the data distribution for ICT-based learning media and students' mathematical understanding ability is normal. Furthermore, the linearity test yielded a Sig. Linearity value of 0.526, also greater than $\alpha = 0.05$, indicating a linear relationship between ICT-based learning media and students' mathematical understanding. Therefore, all assumptions required for simple linear regression analysis were satisfied.

The regression analysis further revealed a significance value of 0.049, which is less than $\alpha = 0.05$. Consequently, the null hypothesis (H_0) is rejected and the alternative hypothesis (H_1) is accepted, indicating that the regression model is statistically significant. The magnitude of the effect of smartphone use on students' mathematical understanding ability in Grade X MIPA at SMA Negeri 6 Karawang is reflected in the coefficient of determination ($R^2 = 0.068$), indicating that 6.8% of the variance in mathematical understanding can be explained by smartphone use at the 5% significance level. This implies that variations in smartphone use (X) contribute to variations in students' mathematical understanding ability (Y_1), as represented by the estimated regression function $\hat{Y} = 218.245 + 2.514X$. The regression coefficient indicates that each one-unit increase in smartphone use is associated with an increase of 2.514 units in students' mathematical understanding scores. Based on these findings, the first hypothesis—proposing a positive effect of smartphone use on students' mathematical understanding ability—is empirically supported. Thus, it can be concluded that smartphone use exerts a positive and statistically significant influence on the mathematical understanding ability of Grade X MIPA students at SMA Negeri 6 Karawang.

This positive effect indicates that smartphone use contributes meaningfully to enhancing students' mathematical understanding. In this study, smartphones function as supplementary learning resources that enable students to access information flexibly, anytime and anywhere, thereby supporting independent and inquiry-based learning. The use of such devices in problem-solving contexts has been shown to increase student engagement and motivation (Peteros et al., 2022). Furthermore, the integration of mobile applications via smartphones in mathematics instruction has been found to improve students' achievement and learning outcomes (Etcuban & Pantinople, 2018). In addition, mobile learning—defined as the use of mobile devices such as smartphones, tablets, and laptops—has been reported to have a moderate positive effect on students' mathematics achievement ($g = 0.476$; $p < .001$; 95% CI [0.335, 0.616]) (Güler et al., 2021).

There is a positive effect of smartphone use on senior high school students' motivation to learn mathematics

The relationship between smartphone use (X) and students' mathematics learning motivation (Y_2) was examined using simple linear regression analysis. As presented in Table 4, the estimation results yielded $\alpha = 71.586$ and $\beta = 0.020$. Substituting these values into the regression equation produces the simple linear regression model: $\hat{Y} = 71.586 + 0.020X$. Prior to conducting the regression analysis, prerequisite tests—including normality and linearity—were performed. The normality test indicated an Asymp. Sig. value of 0.200, exceeding the significance level of $\alpha = 0.05$, thereby confirming that the data distribution for smartphone use and mathematics learning motivation is normal. Furthermore, the linearity test yielded a Sig. Linearity value of 0.983, which is also greater than $\alpha = 0.05$, indicating a linear relationship between smartphone use and students' mathematics learning motivation. Hence, all assumptions required for simple linear regression analysis were satisfied.

Table 4
Results of Hypothesis Testing (Effect of X on Y₂)

Model		Coefficients ^a		t	Sig.
		Unstandardized Coefficients	Standardized Coefficients		
		B	Std. Error	Beta	
1	(Constant)	71.586	114.769		.624
	X	.020	1.501	.002	.039

a. Dependent Variable: Y2

The regression analysis further revealed a significance value of 0.039, which is less than $\alpha = 0.05$. Consequently, the null hypothesis (H_0) is rejected and the alternative hypothesis (H_1) is accepted, confirming the statistical significance of the regression model. The magnitude of the effect of smartphone use on students' mathematics learning motivation is reflected in the coefficient of determination ($R^2 = 0.058$), indicating that 5.8% of the variance in mathematics learning motivation can be explained by smartphone use at the 5% significance level. This implies that variations in smartphone use (X) contribute to variations in mathematics learning motivation (Y), as represented by the estimated regression function $\hat{Y} = 71.586 + 0.020X$. The regression coefficient further indicates that each one-unit increase in smartphone use is associated with an increase of 0.020 units in students' mathematics learning motivation scores.

Based on these findings, the second hypothesis—proposing a positive effect of smartphone use on students' mathematics learning motivation—is empirically supported. Thus, it can be concluded that smartphone use exerts a positive and statistically significant influence on the mathematics learning motivation of tenth-grade senior high school students. This positive effect suggests that smartphone integration contributes beneficially to students' motivation in learning mathematics. In this context, smartphones function as instructional tools that enhance students' engagement and interest during the learning process. Given their pervasive role in daily life, smartphones can make learning experiences more appealing and stimulating. This finding is consistent with prior research indicating that mobile technology-assisted seamless learning environments effectively enhance students' motivation in mathematics learning (Poçan et al., 2022). Moreover, smartphone use can incorporate key elements of effective learning, including motivation, collaboration, and authentic learning experiences (Wijers et al., 2010).

Conclusion

This study provides empirical evidence that smartphone integration in mathematics learning is positively and significantly associated with students' mathematical understanding and learning motivation. The findings indicate that guided smartphone use can serve as a supportive pedagogical tool that facilitates conceptual exploration, access to diverse learning resources, and increased student engagement. Although the magnitude of the relationships is relatively modest, the results underscore the potential of smartphones to contribute meaningfully to both cognitive and affective dimensions of mathematics learning when implemented within structured instructional designs. These findings reinforce the importance of teacher-mediated integration of mobile technologies to maximize their educational value.

Several limitations should be acknowledged. First, the study employed a correlational design, which precludes causal inference regarding the effects of smartphone use on learning outcomes. Second, the relatively small sample size ($n = 57$) drawn from a single school context limits the generalizability of the findings. Third, the reliance on self-reported measures for learning motivation may introduce response bias. Additionally, the study did not account for variations in the quality, type, or intensity of smartphone use, which may differentially influence learning outcomes.

Future research should adopt experimental or quasi-experimental designs to establish causal relationships between smartphone integration and learning outcomes. Expanding the sample across diverse educational settings would enhance the external validity of findings. Further studies are also encouraged to examine the differential impact of specific smartphone-based learning activities, applications, and pedagogical strategies. In addition, integrating qualitative approaches could provide deeper insights into students' learning experiences and the mechanisms through which smartphone use influences mathematical understanding and motivation.

Declaration of Conflicting Interests

The authors report no conflicts of interest related to the research, authorship, and/or publication of this article.

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