



The Effect of Digital Fatigue and Emotional Regulation on Mathematical Problem-Solving Skills

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Abstract

Mathematical problem-solving skills are an important component of mathematics learning because they require concentration, accuracy, and emotional control. In technology-based learning environments, intensive use of digital devices may lead to digital fatigue, which can reduce students' focus, while emotional regulation is considered an important factor that helps students maintain cognitive stability during learning. This study aimed to examine the effect of digital fatigue and emotional regulation on students' mathematical problem-solving skills. The study employed a quantitative approach with a correlational research design. The sample consisted of 34 eleventh-grade students selected using a total sampling technique. Data on digital fatigue and emotional regulation were collected using Likert-scale questionnaires, while mathematical problem-solving skills were measured through descriptive test items. The data were analyzed using multiple linear regression after meeting the required statistical assumptions. The results showed that digital fatigue and emotional regulation did not have a significant effect on students' mathematical problem-solving skills. The R^2 value of 0.023 indicates that the two variables explain only 2.3% of the variance in problem-solving skills. This result may be due to the fact that mathematical problem-solving is more strongly influenced by cognitive factors such as conceptual understanding, reasoning ability, and learning strategies rather than psychological fatigue factors alone. Therefore, future research is recommended to include additional variables such as learning motivation, cognitive strategies, and instructional quality. Practically, teachers are encouraged to strengthen conceptual understanding and problem-solving strategies while maintaining students' psychological well-being in digital learning environments.

Keywords: Digital fatigue; emotional regulation; mathematical problem solving.

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INTRODUCTION

Mathematical problem-solving skills are a form of higher-order thinking that plays a crucial role in the learning process (Agbo et al., 2023). According to Hidayati (2017), these skills include understanding problems, designing solution strategies, applying concepts, and evaluating results logically (Sun et al., 2023). In the learning process, problem-solving is a measure of student success, as it requires them to connect concepts, make decisions, and persevere when encountering difficulties (Sinha & Kapur, 2021). In principle, mathematics education is designed to cultivate students' critical thinking and their ability to address complex problems. Nevertheless, in practice, many students still

encounter difficulties when attempting to solve mathematical problems effectively, particularly within technology-supported learning environments. However, intensive digital learning carries the risk of digital fatigue, which is exhaustion due to excessive use of digital devices and can reduce students' focus and effectiveness in thinking when solving mathematical problems.

Digital fatigue refers to a state of mental, emotional, and physical exhaustion caused by excessive use of digital devices over a prolonged period (Supriyadi et al., 2025; Arican, 2025). Based on this view, digital fatigue can be interpreted as a decrease in students' ability to maintain concentration, motivation, and effective thinking during the learning process, especially when the use of digital devices is too long, thereby impacting their engagement and academic performance, particularly in subjects such as mathematics that require high focus and accuracy (Anggeriani & Ain, 2024). In addition, digital fatigue can also affect students' emotional stability, making emotional regulation skills important for maintaining focus and balance during learning (Neagu & Vieriu, 2025).

Emotional regulation refers to an individual's ability to recognize, control, and express emotions appropriately in order to adapt to various situations (Garc, 2019). Zajenkowski et al. (2022) explain that emotional regulation involves how individuals influence the emotions they experience, including when they arise and how they are expressed. Furthermore, emotional regulation also includes conscious and unconscious mechanisms used to adjust emotional responses to specific contexts in mathematical learning (Bura, 2023). Emotional regulation enables students to manage feelings such as frustration, anxiety, and pressure so that they can remain focused, persistent, and able to apply appropriate problem-solving strategies (Muna, 2024). Conversely, difficulties in managing emotions may reduce learning motivation and hinder logical thinking processes during problem-solving activities (Jarar, 2024).

Various studies show that digital fatigue has a significant impact on the decline in student learning quality. Research conducted Gumasing and Castro (2023) revealed that the intensity of digital device use during online learning can cause cognitive fatigue, resulting in low student participation in the learning process. Similar results were found by Han (2024) those who identified a negative relationship between digital fatigue and learning motivation and academic achievement. A study conducted by Noenoek (2024) involving 200 students revealed that higher levels of digital fatigue were significantly associated with lower academic achievement, as indicated by a negative correlation coefficient and a significance value of $p < 0.05$. These results are consistent with international research by Seresirikachorn et al. (2022) involving 2,476 high school students in Thailand, where the average duration of digital device use reached 10.53 ± 2.99 hours per day during online learning, a sharp increase compared to before the pandemic (approximately 6.13 ± 2.8 hours per day). More than 70% of respondents reported experiencing symptoms of computer vision syndrome (CVS), which is closely correlated with the length of screen exposure and the level of digital fatigue. Based on cognitive load theory, excessive digital exposure may reduce students' cognitive efficiency when processing complex information.

Research findings on emotional regulation show that this ability contributes significantly to students' academic achievement, especially in mathematics learning, which often causes emotional stress (Pablo & Alberto, 2021). A study by Amekauma (2024) found that positive emotional management, such as self-confidence, perseverance, and enthusiasm, plays an important role in improving mathematics learning outcomes. Similar findings were revealed by Hiltrimartin (2025) who stated that good emotional regulation can maintain students' motivation, mental resilience, and perseverance in facing learning difficulties. Therefore, emotional regulation can be seen as a crucial element in improving mathematical problem-solving skills. In addition, Schoenherr et al. (2025)'s meta-analysis

of studies on emotions in mathematics learning revealed that positive emotions such as enjoyment, hope, and pride were positively correlated with mathematics achievement, with average correlations of $r= 0.247, 0.224,$ and $0.344,$ respectively. while negative emotions such as anger, boredom, frustration, despair, and shame showed a significant negative correlation with mathematics achievement ($- 0.322; - 0.187; - 0.207; - 0.378; - 0.291$). These findings suggest that digital fatigue and emotional regulation may influence students' cognitive engagement in solving mathematical problems.

Several recent studies have begun to examine the relationship between digital fatigue, emotional regulation, and student academic achievement. A study by Schöbel et al. (2023) revealed that digital fatigue has a negative impact on emotional management skills, which in turn affects reflective thinking and problem-solving strategies. Similar results were reported by Ng et al. (2022) who showed that intensive use of digital technology can trigger stress and emotional disturbances that hinder students' ability to develop strategies for solving math problems. Another study by Queiroz (2022) assessing changes in sleep quality and student productivity during distance learning showed that all respondents used screens continuously before bedtime. As a result, 77.2% of students reported that their academic performance was "poor" to "very poor," with 65.9% experiencing decreased productivity due to daytime sleepiness.

Although several studies have examined digital fatigue and emotional regulation in learning contexts, most previous studies have tended to analyze these variables separately rather than examining their combined influence on students' mathematical problem-solving skills. Previous research has shown that digital fatigue may reduce students' concentration and learning motivation, while emotional regulation plays an important role in maintaining persistence and cognitive engagement in mathematics learning. However, empirical studies that integrate digital fatigue and emotional regulation simultaneously within a predictive analytical model of mathematical problem-solving skills remain limited, particularly in the context of secondary education. Considering that mathematical problem-solving skills is influenced by both cognitive and affective factors, examining the combined influence of these two psychological variables becomes important to obtain a more comprehensive understanding of students' learning processes in digital environments. Therefore, this study aims to analyze the effect of digital fatigue and emotional regulation on students' mathematical problem-solving skills using a multiple linear regression model.

METHODS

This study applies a quantitative approach with a correlational design to analyze the relationship between digital fatigue and emotional regulation on students' ability to solve mathematical problems (Ibrahim et al., 2024). The main focus is to explore the contribution of these two psychological variables to the effectiveness of students' ability to solve mathematical problems (Da et al., 2019). The correlation design was chosen based on its ability to test the relationship between variables objectively through numerical data (Devi & Lepcha, 2023), while also providing an empirical description that serves as the foundation for developing adaptive learning strategies to face the challenges of the digital environment (Martin et al., 2020).

The population of this study consisted of all eleventh-grade students at SMAN 8 Mataram. A total of 34 students were involved as the sample using a total sampling technique, in which all members of the population were included because the population size was relatively small. Digital fatigue (X_1) and emotional regulation (X_2) were measured using a five-point Likert scale consisting of eight statements each. Mathematical problem-solving skills (Y) were assessed using five descriptive questions covering the indicators of

understanding problems, planning strategies, implementing solutions, and drawing conclusions. Before data collection, the instruments were tested for validity using the Pearson Product Moment correlation and for reliability using Cronbach's Alpha. An item was considered valid if $r_{\text{count}} > r_{\text{table}}$ at a significance level of 0.05, while the instrument was considered reliable if the Cronbach's Alpha value exceeded 0.70. A research flowchart illustrating the stages of the study is presented in Figure 1.

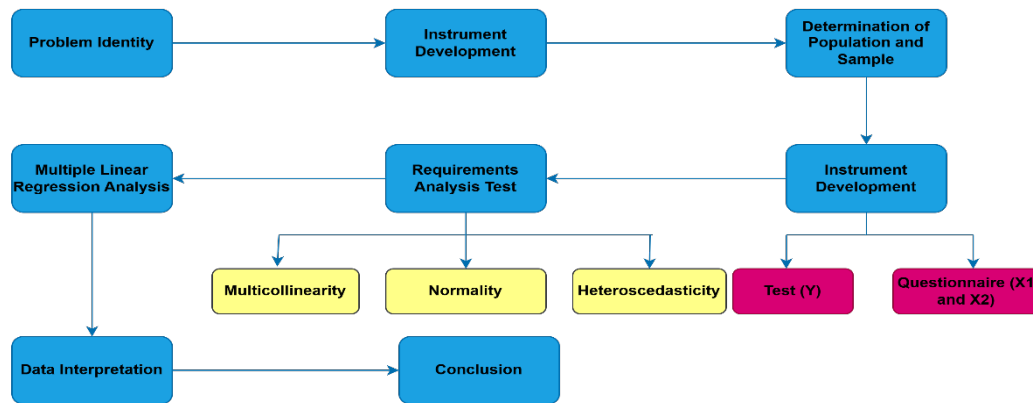


Figure 1. Research process

Figure 1 presents the flow of quantitative research using a multiple linear regression analysis approach, which is carried out systematically and structurally. The research stages begin with problem identification to explore empirical gaps and strengthen the theoretical basis behind the research. Next, the process continues with the development of instruments and the determination of the population and sample, which aims to ensure that the research instruments are appropriate for the characteristics of the respondents and can measure variables accurately. In the instrument development stage, the independent variables (X_1 and X_2) are measured using a questionnaire, while the dependent variable (Y) is measured through a test.

After the instruments were administered and the data were collected, the analysis was conducted in several systematic stages. The first stage involved descriptive statistical analysis to provide an overview of the research variables. The next stage was testing the classical assumptions, including normality, multicollinearity, and heteroscedasticity tests, to ensure that the data met the requirements for multiple linear regression analysis. If the data satisfied these assumptions, multiple linear regression analysis was performed to examine the effect of digital fatigue (X_1) and emotional regulation (X_2) on mathematical problem-solving skills (Y), followed by hypothesis testing to determine the significance of the relationships between variables. The results were then interpreted by considering theoretical perspectives and relevant empirical findings. The final stage involved drawing conclusions that summarize the main findings as well as their theoretical and practical implications. A complete description of the indicators for each variable is presented in Table 1.

Table 1. Research Instrument Indicators

Variable	Indicator	Source
<u>Digital Fatigue (X₁)</u>	1. Feeling tired when using digital devices	(Lepp et al., 2022)
1. Emotional Fatigue	2. Losing motivation to study because of digital screens	
2. Cognitive Fatigue	1. Difficulty concentrating when studying online	(Webster & Hadwin, 2015)
	2. Difficulty understanding material due to excessive digital exposure	
<u>Emotional Regulation (X₂)</u>	1. Able to recognize emotions while studying	(Webster & Hadwin, 2015)
1. Emotional Awareness	2. Aware of mood swings while studying	
2. Emotional Control	1. Able to manage stress when tasks pile up	(Hendrycks et al., 2021);(Chen et al., 2020);(Metcalf & Eich, 2019)
	2. Avoid negative reactions when failing to understand the material	
<u>Problem Solving Skills (Y)</u>	1. Able to understand mathematical problems	(Hendrycks et al., 2021);(Chen et al., 2020);(Metcalf & Eich, 2019)
1. Emotional Control	2. Determine important information from the question	
2. Problem Solving Strategies	1. Organize the steps to solve the problem correctly	
3. Implementing Solutions	2. Use alternative strategies if unsuccessful	
4. Drawing Conclusions	Complete the steps to solve the problem in a logical sequence. Write down the final answer and check its correctness.	

Table 1 shows the formulation of indicators for each variable that forms the basis for the research instrument. The indicators for the digital fatigue variable are designed to measure the level of student fatigue resulting from the use of digital devices in learning activities. For the emotional regulation variable, the indicators emphasize students' ability to recognize and control their emotions. Meanwhile, the indicators for the mathematical problem-solving skills variable are designed to assess students' ability to understand problems, choose solution strategies, apply solution steps, and draw accurate conclusions. This set of indicators is used to develop questionnaire and test items to obtain accurate data in line with the research objectives.

RESULTS & DISCUSSION

Results

The preliminary summary of the research findings begins with a presentation of descriptive data on each indicator variable studied. Graphs of the average digital fatigue (X₁) and emotional regulation (X₂) indicators are displayed to provide an overview of the respondents' answer trends before proceeding to further statistical analysis. The presentation of these diagrams helps to show the initial patterns of each variable, thereby facilitating understanding of the research data characteristics. The visualization of the average values of X₁ and X₂ is shown in Figure 2.

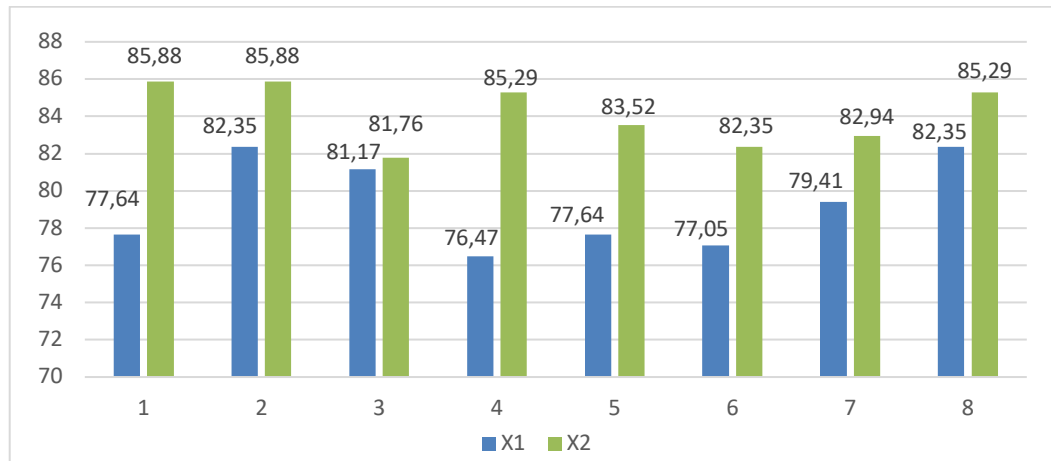


Figure 2. Average values of indicators X₁ and X₂

Figure 2 shows that the average value of the emotional regulation indicator X₂ is consistently higher than the digital fatigue indicator X₁. The X₂ indicator ranges from 82 to 86, indicating that participants' emotional regulation is relatively high and stable across indicators. Meanwhile, the average value for X₁ ranges from 76 to 82, indicating more varied levels of digital fatigue among participants. The next stage is descriptive statistical analysis to identify value distribution, average trends, and variation in each variable. Through this analysis, the conditions of Digital Fatigue X₁, Emotional Regulation X₂, and Mathematical problem-solving skills Y can be understood before inferential statistical testing. The summary results are presented in Table 2.

Table 2. Descriptive Statistics

	X ₁	X ₂	Y
Mean	68.911	72.823	59.676
Median	69	72	60
Mode	63	78	66
Std. Deviation	12.422	9.752	11.310
Maximum	89	92	78
Minimum	45	50	35

Table 2 presents the descriptive statistics of the research variables. The Digital Fatigue of variable X₁ has a mean score of 68.911, a median of 69, a mode of 63, and a standard deviation of 12.422, with scores ranging from 45 to 89, indicating a moderate level of digital fatigue with varied responses among students. The Emotional Regulation of variable X₂ has a mean score of 72.823, a median of 72, a mode of 78, and a standard deviation of 9.752, with scores ranging from 50 to 92, reflecting students' emotional regulation abilities with moderate variation. Meanwhile, the Mathematical problem-solving skills variable Y has a mean score of 59.676, a median of 60, a mode of 66, and a standard deviation of 11.310, with scores ranging from 35 to 78, indicating varied problem-solving skills among students. Before conducting regression analysis, a normality test was performed to ensure that the data distribution met the assumptions for parametric analysis, therefore the Kolmogorov–Smirnov and Shapiro–Wilk tests were applied, and the results are presented in Table 3.

Table 3. Tests of Normality

	Kolmogorov-Smirnov ^a		Shapiro-Wilk	
	Statistic	Sig.	Statistic	Sig.
X ₁	.079	.200*	.965	.333
X ₂	.114	.200*	.983	.864
Y	.077	.200*	.965	.343

Table 3 shows that all research variables (X₁, X₂, and Y) have significance values greater than 0.05 in both the Kolmogorov–Smirnov and Shapiro–Wilk tests. These results indicate that the data are normally distributed and meet the normality assumption required for parametric analysis. Therefore, the data are suitable for further analysis using multiple linear regression. After confirming normality, a multicollinearity test was conducted to examine the correlation among the independent variables by evaluating the Tolerance and Variance Inflation Factor (VIF) values. The results of this test are presented in Table 4.

Table 4. Multicollinearity Test Results

Variables	Tolerance	VIF
X ₁	0.507	1.974
X ₂	0.507	1.974

Table 4 indicates that the Tolerance values for variables X₁ and X₂ are 0.507, while the VIF values are 1.974. These values meet the multicollinearity requirements, namely Tolerance greater than 0.10 and VIF less than 10. Thus, the regression model is free from multicollinearity, allowing the analysis to proceed to the multiple linear regression stage. The next step is testing for heteroscedasticity to verify the constancy of residual variance across predicted values. The test is conducted using the Glejser method by examining the significance values in the Coefficient table. The model is free of heteroscedasticity if the significance value of each independent variable is greater than 0.05. The results are presented in Table 5.

Table 5. Heteroscedasticity test results

Variables	Sig
X ₁	0.939
X ₂	0.835

Table 5 indicates that the significance value for variable X₁ is 0.939 and variable X₂ is 0.835. Since these values exceed the threshold of 0.05, the regression model shows no indication of heteroscedasticity, and the residual variance is homogeneous. Thus, the model meets the homoscedasticity assumption, and the analysis can proceed to the next stage. After all prerequisite tests are met, multiple linear regression analysis is conducted to evaluate the contribution of independent variables X₁ and X₂ to the dependent variable Y. The initial step is examining the Model Summary Table, which shows the strength of the relationship between variables and the proportion of variance in the dependent variable explained by the independent variables. The results are presented in Table 6.

Table 6. Model Summary

R	R Square	Adjusted R Square	Std. Error of the Estimate
.151 ^a	.023	-.040	11.536

Table 6 indicates that the R value of 0.151 reflects a very weak relationship between digital fatigue and emotional regulation on mathematical problem-solving skills. The R-squared value of 0.023 shows that the model explains only 2.3 % of the variation in

problem-solving skills, while the Adjusted R-squared value of 0.040 indicates low accuracy of the model in predicting the dependent variable. Meanwhile, the Standard Error of the Estimate of 11.536 indicates a relatively high prediction error. Overall, the two independent variables did not contribute significantly to students' mathematical problem-solving skills, as also confirmed by the ANOVA test results presented in Table 7.

Table 7. Anova^a

Model		Sum of Squares	df	Mean Square	f	Sig.
1	Regression	96.130	2	48.065	.361	.700 ^b
	Residual	4125.311	31	133.075		
	Total	4221.441	33			

Table 7 reveals that the ANOVA test produced an F value of 0.361 with a significance level of 0.700, which exceeds the threshold of 0.05. These results indicate that the regression model including digital fatigue and emotional regulation is not statistically significant in explaining the variation in students' mathematical problem-solving skills. The Mean Square Regression of 48.065 is lower than the Mean Square Residual of 133.075, indicating that most data variation is influenced by factors outside the model. Thus, the regression model cannot be used to predict the dependent variable. Further analysis of the Coefficients Table is needed to examine the contribution of each variable individually, as presented in Table 8.

Table 8. Coefficients^a

Model		Unstandardized Coefficients		Standardized Coefficients		t	Sig.
		B	Std. Error	Beta			
1	(Constant)	63.619	16.296			3.904	.000
	X1	-.175	.208	-.170		-.841	.407
	X2	.118	.231	.103		.511	.613

Table 8 shows that the constant value of 63.619 is significant at 0.000, indicating that when digital fatigue X_1 and emotional regulation X_2 are at their minimum, mathematical problem-solving skills Y is at this baseline. The coefficient of digital fatigue X_1 is -0.175 with a significance of 0.407. The regression equation is presented in Equation (1).

$$Y = 63.619 - 0.175 X_1 + 0.118 X_2 \quad (1)$$

Given that the significance value exceeds 0.05, the variable does not show a significant effect on mathematical problem-solving skills. Although the coefficient describes a negative relationship, the impact is not strong enough to be considered statistically significant. Meanwhile, emotional regulation (X_2) shows a coefficient of 0.118 with a significance value of 0.613, which is also above the 0.05 threshold. These results indicate that emotional regulation does not have a significant effect on students' mathematical problem-solving skills. Although the direction of the relationship is positive, its strength is insufficient to form a substantial correlation.

Discussion

The results of this study indicate that digital fatigue (X_1) has a Beta regression coefficient of -0.175 with a significance level of 0.407, meaning that its effect is negative

but not significant on mathematical problem-solving skills. This finding is consistent with Alarabiat (2024) who reported a very weak and insignificant relationship between the two variables with a correlation coefficient of -0.119 and a significance value of 0.171 . From a theoretical perspective, this result can be explained through cognitive load theory, which suggests that mathematical problem-solving skills is primarily influenced by internal cognitive factors such as prior knowledge, reasoning ability, and conceptual understanding. In this context, digital fatigue may slightly reduce students' attention or concentration, but its influence is not strong enough to directly affect their ability to construct solution strategies for mathematical problems. Therefore, both significance values exceeding 0.05 confirm that there is no significant effect on the mathematical problem-solving skills of the respondents in this study. Students may also adopt adaptive strategies, such as adjusting their learning pace or relying on prior knowledge, which helps them maintain their problem-solving performance despite experiencing digital fatigue.

These findings differ from previous studies highlighting the significant role of emotional factors in academic performance. For example Abdelrahman et al. (2025) found that emotional intelligence strongly predicts academic resilience with an unstandardized coefficient of 0.57 , a standardized coefficient of 0.66 , and a significance value less than 0.001 . Similarly, Shen (2025) reported that positive emotions like enjoyment correlate positively with mathematics achievement with r approximately 0.247 , while negative emotions like frustration correlate negatively with r approximately minus 0.207 .

These findings illustrate that emotional factors generally contribute to mathematics achievement in various studies. Dharmawan et al., (2024) Research on mixed approaches that examine social media usage behavior and social fatigue symptoms shows that the relationship between social and digital fatigue and academic achievement is quite complex. In some studies, this influence appears to be direct, while in other studies the effect is mediated by factors such as procrastination or certain coping strategies. This complexity then gives rise to variations and inconsistencies in findings between studies. This suggests that the effect of digital fatigue on academic performance may occur indirectly through factors such as motivation or self-regulated learning.

While the Emotional regulation variable (X_2), this study obtained a regression coefficient of 0.118 with a significance value of 0.613 , indicating that although the effect moved in a positive direction, it was not statistically significant. This result differs from studies that found that emotional regulation plays a significant role in improving cognitive performance. This finding is not in line with the study conducted by Lu et al. (2025) which stated that the coefficient was stronger, namely Beta 0.37 with $p < 0.01$. One possible explanation is that emotional regulation may influence learning outcomes indirectly through factors such as motivation and self-regulated learning. In mathematics learning, therefore, emotional regulation may support learning indirectly by maintaining motivation, persistence, and engagement during the problem-solving process.

Theoretically, these findings suggest that digital fatigue and emotional regulation function more as supporting psychological factors than direct predictors of mathematical problem-solving skills. Practically, mathematics instruction in digital learning environments should emphasize conceptual understanding and structured problem-solving practice. This study has several limitations that need to be considered. The relatively small sample size and the use of self-report instruments have the potential to affect the accuracy of digital fatigue and emotion regulation measurements. In addition, the cross-sectional design of the study limits the interpretation of the direction of the relationship between variables. This study also did not include other variables that have been proven in various studies to be related to academic performance, thus limiting the scope of the analysis.

CONCLUSION

The results of this study indicate that digital fatigue and emotional regulation do not significantly contribute to students' mathematical problem-solving skills and explain only 2.3% of the variance, suggesting that most of the variation is influenced by other factors; therefore, they cannot be considered the main predictors of students' mathematical problem-solving performance.

These findings imply that mathematical problem-solving skills are shaped by multiple factors beyond the psychological variables examined in this study. Future research is recommended to incorporate additional variables, such as learning motivation, learning strategies, and instructional methods, to obtain a more comprehensive understanding. Practically, educators should continue to monitor students' psychological conditions in digital learning environments while also strengthening conceptual understanding and structured problem-solving strategies in mathematics instruction.

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