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The Influence of Emotional Intelligence and Learning Motivation on Mathematical Critical Thinking Ability

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A B S T R A K

This survey research with multiple regression analysis aims to: (1) determine the joint influence of emotional intelligence and learning motivation on mathematical critical thinking ability; (2) determine the influence of emotional intelligence on mathematical critical thinking ability; and (3) determine the influence of learning motivation on mathematical critical thinking ability. The research was conducted at SMA Negeri 1 Sinunukan, Mandailing Natal, North Sumatra, Indonesia, in the odd semester of the 2025/2026 academic year. The sampling technique was simple random sampling, with 180 respondents drawn from an accessible population of 380 students. Instruments included questionnaires for emotional intelligence and learning motivation, and essay tests for mathematical critical thinking ability. All items were empirically validated. Hypothesis testing was conducted after fulfilling classical assumption tests (normality, linearity, multicollinearity). Multiple regression with F-test and partial hypothesis testing with t-test were used. Results show: (1) significant joint influence of emotional intelligence and learning motivation on mathematical critical thinking ability ($R^2 = 0.699$); (2) significant influence of emotional intelligence (contribution 15.6%); (3) significant influence of learning motivation (contribution 54.3%).

1. INTRODUCTION

The Indonesian education system continues to undergo significant transformation, most recently through the implementation of the *Merdeka Curriculum* (Kurikulum Merdeka), which emphasizes critical thinking, creativity, and character development. However, the 2022 Programme for International Student Assessment (PISA) results revealed that Indonesian students still rank low in mathematical literacy and critical thinking skills, with an average score of 366, far below the OECD average of 472 (OECD, 2023). These findings indicate that improving the quality of human resources through effective teaching and learning processes remains a national priority. One of the key internal factors contributing to students' low critical thinking ability in mathematics is the lack of emotional regulation and learning motivation, both of which are essential for solving complex, non-routine problems (Suharti & Zulkarnain, 2021).

Emotional intelligence plays a vital role in helping students manage frustration, anxiety, and self-doubt when facing difficult mathematical tasks. Recent studies by Wahyuni and Pratama (2022) and Hasanah et al. (2023) confirm that students with higher emotional intelligence tend to demonstrate better critical thinking skills because they can regulate their emotions, persist through challenges, and reflect on their problem-solving processes (Yang, C., Wei, M. & Liu, Q., 2025). In contrast, students with low emotional intelligence often give up easily and fail to analyze problems systematically. Given the increasing complexity of 21st-century mathematics education, which requires students to evaluate information, construct arguments, and make reasoned decisions, emotional intelligence has become a crucial non-cognitive factor that cannot be ignored (Ningsih & Hidayat, 2024).

Similarly, learning motivation—both intrinsic and extrinsic—has been identified as a dominant predictor of critical thinking ability in mathematics. Research by Firmansyah and Kurniawan (2021) and Lestari & Sari (2023) shows that motivated students actively seek alternative solutions, engage in self-regulated learning, and demonstrate higher levels of analytical thinking. The shift toward student-centered learning models in the Merdeka Curriculum further amplifies the need for strong internal motivation, as students are expected to take ownership of their learning process. Therefore, this study aims to: (1) determine the joint influence of emotional intelligence and learning motivation on mathematical critical thinking ability; (2) determine the partial influence of emotional intelligence; and (3) determine the partial influence of learning motivation. The research was conducted at SMA Negeri 1

Sinunukan, Mandailing Natal, North Sumatra, Indonesia, during the odd semester of the 2025/2026 academic year.

Education is a conscious, regular, and planned effort undertaken by humans to develop the potential of human resources. In realizing the goals of national education, these efforts should be implemented through teaching and learning activities in schools. Schools are formal institutions that serve as a means to achieve national education goals (Tanjung, W. K. A., Jupri, A., & Usdiyana, D., 2025). At school, students participate in learning activities organized by the school. These teaching and learning activities must run effectively so that schools can produce competent graduates who meet national education standards. However, in reality, these teaching and learning activities are not yet fully effective (Yang, C., Wei, M. & Liu, Q., 2025). The effectiveness of learning can be supported by several factors, including internal and external factors.

One internal factor supporting learning is thinking ability. Through learning activities, students are required to understand the subject matter. Understanding the material in each subject is largely determined by the thinking abilities possessed by each student, including critical thinking skills. Critical thinking skills are very useful in the learning process of students in every subject, including mathematics. Mathematics is a subject studied from kindergarten to higher education. Mathematics is closely related to its application in daily life (Tanjung, W. K. A., Jupri, A., & Usdiyana, D., 2025). The concept of mathematics is very closely tied to critical thinking. Generally, mathematics is associated with numbers and formulas, so critical thinking skills are needed to solve mathematical problems. Many people think that mathematics is a difficult subject, causing many students to feel insecure and easily give up when solving problems. When they make a calculation error, they prefer to give up rather than continue calculating because they think they cannot solve the mathematical problem. This situation arises because they have relatively low critical thinking skills. (Yang, C., Wei, M. & Liu, Q., 2025)

Many factors influence a person's critical thinking ability. One of them is the emotional condition within the individual. Emotional condition here refers to the emotional state characterized by various feelings that arise and fluctuate when facing or experiencing a particular event (Kusuma, R. A., et al. 2024). A person is expected to be able to control their emotions through good and positive emotional management. In managing emotions, a person is certainly required to have good emotional intelligence. Emotional intelligence can influence a person's critical thinking ability. The better a person's emotional intelligence, the greater the likelihood that their critical thinking ability will also improve. (Soriano-Sánchez, J., & Jiménez-Vázquez, D., 2022)

Critical thinking ability is influenced by a wide range of interrelated factors, one of which is the individual's emotional condition. Emotional condition refers to the dynamic psychological state characterized by various feelings that emerge and fluctuate when a person encounters specific situations or experiences. These emotional responses can either facilitate or hinder cognitive processes, depending on how they are managed (Kusuma, R. A., et al. 2024). In academic contexts, particularly in mathematics learning, students often face complex and demanding problems that can trigger emotions such as anxiety, frustration, or confusion. If these emotions are not properly regulated, they may disrupt concentration and reduce the effectiveness of reasoning processes (Alenezi, A.M., 2020). Conversely, stable and well managed emotions can create a supportive internal environment for analytical thinking. Therefore, emotional condition plays a crucial role in shaping how individuals process information and respond to intellectual challenges. (Amador-Licona, N., et al. 2021)

To manage emotional conditions effectively, individuals are required to develop strong emotional intelligence. Emotional intelligence refers to the ability to recognize, understand, regulate, and utilize emotions in a constructive manner. It involves key competencies such as self awareness, self regulation, empathy, and social skills, all of which contribute to better psychological adjustment and decision making. Individuals with high emotional intelligence are more capable of maintaining emotional balance when facing difficult or unfamiliar tasks (Amaya-Conforme, D.R., y Yánez-Rodríguez, M.A, 2021). This stability allows them to remain focused, think clearly, and avoid impulsive reactions that may interfere with problem solving. In the context of learning, emotionally intelligent students are better equipped to handle academic pressure and sustain engagement in cognitively demanding activities. As a result, emotional intelligence becomes an essential internal resource that supports effective thinking processes. (Azilah, N.L., Devi, I., y Zainal, N., 2020)

Furthermore, emotional intelligence has a direct and indirect influence on critical thinking ability. From a direct perspective, the ability to regulate emotions enables individuals to engage in reflective and rational analysis without being overwhelmed by negative feelings (Azilah, N.L., Devi, I., y Zainal, N., 2020). This enhances their capacity to evaluate information objectively, consider multiple perspectives, and make reasoned judgments. Indirectly, emotional intelligence also promotes positive learning behaviors such as persistence, resilience, and openness to new ideas, which are closely associated with critical thinking (Amaya-

Conforme, D.R., y Yánez-Rodríguez, M.A, 2021). For example, a student who can manage frustration is more likely to persist in solving complex problems rather than giving up prematurely. This persistence allows for deeper cognitive engagement and the development of more sophisticated reasoning skills. Thus, emotional intelligence not only supports the cognitive dimension of thinking but also strengthens the behavioral processes underlying it. (Azilah, N.L., Devi, I., y Zainal, N., 2020)

The relationship between emotional intelligence and critical thinking ability is both significant and complementary. The better an individual's emotional intelligence, the greater the likelihood that their critical thinking skills will develop effectively. Emotional intelligence provides the psychological foundation that enables individuals to navigate challenges, regulate their responses, and engage in thoughtful analysis. Without adequate emotional control, even individuals with strong cognitive potential may struggle to perform optimally (Ska, S., & Halder, S., 2020). Therefore, efforts to improve critical thinking should also include the development of emotional competencies as an integral component of education. By fostering emotional intelligence, educators can help students build a more balanced and resilient approach to learning. Ultimately, this integration contributes to the enhancement of both academic performance and overall intellectual growth. (Bustamante-Mora, A., et al. 2025)

The importance of emotional intelligence is felt when a person interacts with other individuals or groups. Emotional intelligence is a person's ability to manage their emotions. This emotional management can affect various daily activities, including learning activities. The theory of emotional intelligence is also supported by research conducted by Adriyati and Nursa'adah (2015), which showed that there is a significant influence of emotional intelligence on students' mathematical critical thinking.

Another factor that may influence critical thinking ability is motivation. High motivation is reflected in learning capacity, risk-taking, answering questions, and willingness to take responsibility. The stronger a person's motivation, the better their critical thinking ability. Even if they do not have good critical thinking skills, they will continuously optimize themselves to achieve maximum critical thinking ability. This can happen because they have strong motivation from within themselves. (Ska, S., & Halder, S., 2020)

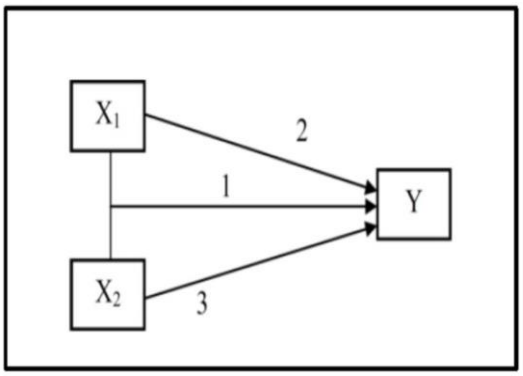
Students in mathematics learning often face difficulties when completing assignments given by the teacher. If students have good emotional intelligence and learning motivation, they will continue to try to find ways to complete the task (Bustamante-Mora, A., et al. 2025). Various alternative ways include borrowing books from the library or seeking information from the internet related to the subject matter they are facing. Such strong efforts are certainly based on good emotional management and motivation within the students. From strong emotional intelligence and learning motivation, a person's thinking ability, including critical thinking skills, will improve (Gkintoni, E., Halkiopoulos, C., Dimakos, I., & Nikolaou, G., 2023). If they feel that the math assignment is too difficult, they may give up, which is due to their relatively low level of emotional intelligence and learning motivation, resulting in less-than-maximum critical thinking ability.

2. RESEARCH METHOD

This research on the influence of emotional intelligence and learning motivation on mathematical critical thinking ability was conducted on tenth-grade students at SMA Negeri 1 Sinunukan, Mandailing Natal Regency, North Sumatra, Indonesia. The school is located at Jalan Pendidikan Lintas Batahan-Sinunukan No. 1, Sinunukan District, Postal Code 22988. The research was conducted from July to December 2025 (odd semester of the 2025/2026 academic year) and employed a correlational survey design with multiple regression analysis.

2.1 Research Design

The research design is illustrated in Figure 1.



Description:
X_1 = Emotional Intelligence
X_2 = Learning Motivation
Y = Mathematical Critical Thinking Ability
1 = Joint influence of X_1 and X_2 on Y
2 = Influence of X_1 on Y
3 = Influence of X_2 on Y

2.2 Population and Sample

The target population was all students at SMA Negeri 1 Sinunukan in the 2025/2026 academic year. The accessible population was tenth-grade students consisting of 7 parallel classes, totaling 380 students.

Simple random sampling (lottery method) was used to select 180 students as the sample, determined using the Taro Yamane formula (Riduwan, 2006:65).

2.3 Instruments

Instruments included non-test questionnaires for emotional intelligence (X_1) and learning motivation (X_2), and an essay test for mathematical critical thinking ability (Y). All instruments were validated through content validity (expert judgment by three experts) and empirical validity (trial on 30 non-sample students).

a. **Critical Thinking Instrument (Essay):** Based on Ennis (2011) indicators: (1) Problem definition and clarification; (2) Evaluating information related to the problem; (3) Problem-solving or drawing conclusions.

b. **Emotional Intelligence Questionnaire (30 items):** Based on Zuchdi (2009) indicators: recognizing one's own emotions, managing emotions, self-motivation, recognizing others' emotions, and building relationships. After empirical testing, 22 valid items were retained (validity coefficients: 0.341–0.718; reliability: 0.931).

c. **Learning Motivation Questionnaire (48 initial items):** Based on Sardiman (2001) and Uno (2008) indicators: desire for success, awareness of learning needs, future aspirations, appreciation, interest, perseverance, resilience, independence, etc. After testing, 39 valid items were retained (validity coefficients: 0.341–0.718; reliability: 0.931).

2.4 Data Analysis

Data were analyzed descriptively (mean, median, mode) and inferentially (multiple regression, F-test, t-test) after testing classical assumptions: normality (Chi-Square), linearity (F-test), and multicollinearity (VIF). All calculations used Microsoft Excel.

3. RESULTS AND DISCUSSION

3.1 Descriptive Statistics

The sample consisted of 180 students (male = 72, female = 108), heterogeneous in cognitive ability (high, medium, low groups based on mathematics achievement). Table 1 summarizes descriptive statistics.

Table 1. Descriptive Statistics Summary

Statistic	Critical Thinking	Emotional Intelligence	Learning Motivation
Lowest Score	66	47	67
Highest Score	190	95	184
Mean	133.94	74.90	124.40
Median	131.00	76.00	122.00
Mode	120	80	115
Variance	498.85	98.53	428.09
Std. Deviation	22.34	9.93	20.69

Table 1 presents a comprehensive descriptive statistical summary of three key constructs, namely critical thinking, emotional intelligence, and learning motivation, providing an initial empirical overview of the data distribution. The range of scores indicates substantial variability across all variables, with critical thinking exhibiting values between 66 and 190, emotional intelligence ranging from 47 to 95, and learning motivation spanning from 67 to 184. These intervals suggest that respondents demonstrate heterogeneous characteristics, which is particularly relevant in educational research contexts where individual differences play a crucial role. The relatively wide score dispersion in critical thinking and learning motivation implies the presence of diverse cognitive and affective profiles among participants. In contrast, emotional intelligence displays a narrower range, suggesting relatively more homogeneous responses. Such variability is essential for inferential analysis, as it enables the detection of meaningful relationships among variables. Overall, these descriptive indicators provide a foundational understanding of the dataset prior to conducting more advanced statistical procedures.

The measures of central tendency further illuminate the distributional characteristics of each variable. The mean scores for critical thinking, emotional intelligence, and learning motivation are 133.94, 74.90, and 124.40, respectively, indicating moderate to relatively high levels across all constructs. When compared with the median values—131.00 for critical thinking, 76.00 for

emotional intelligence, and 122.00 for learning motivation—it can be observed that the distributions are relatively symmetrical, with only slight deviations. The proximity between mean and median suggests the absence of extreme skewness, thereby supporting the assumption of normality in the dataset. Additionally, the mode values (120 for critical thinking, 80 for emotional intelligence, and 115 for learning motivation) indicate the most frequently occurring scores, which are generally close to the central tendency measures. This alignment reinforces the stability and consistency of the data distribution. Such findings are important in validating the appropriateness of parametric statistical analyses in subsequent stages of the research.

The dispersion measures, including variance and standard deviation, provide deeper insights into the spread and consistency of the data. Critical thinking exhibits the highest variance (498.85) and standard deviation (22.34), indicating a relatively large spread of scores around the mean. Similarly, learning motivation also shows substantial variability, with a variance of 428.09 and a standard deviation of 20.69, suggesting diverse levels of motivational engagement among participants. In contrast, emotional intelligence demonstrates comparatively lower variability, as reflected by its variance of 98.53 and standard deviation of 9.93. This indicates that participants' emotional intelligence levels are more clustered around the mean, implying greater uniformity (Ska, S., & Halder, S., 2020). The differences in variability across variables highlight the distinct nature of cognitive and affective constructs, where cognitive abilities and motivation tend to fluctuate more widely than emotional competencies. Such distinctions are critical for interpreting the robustness and generalizability of the findings.

The overall statistical profile suggests that the dataset is sufficiently robust for further inferential and multivariate analyses. The absence of extreme outliers, as implied by the alignment between mean, median, and mode, enhances the reliability of the data (Gkintoni, E., Halkiopoulos, C., Dimakos, I., & Nikolaou, G., 2023). The relatively high mean scores across variables may indicate a generally favorable level of critical thinking, emotional intelligence, and learning motivation among respondents, which could be influenced by contextual or pedagogical factors (Zhao, H., Zhang, H., Li, J. & Liu, H., 2025). Moreover, the balanced distribution patterns support the assumption that the sample adequately represents the target population. These descriptive findings serve as a crucial preliminary step in identifying patterns and relationships among variables before hypothesis testing (Ska, S., & Halder, S., 2020). From a methodological perspective, such comprehensive descriptive analysis strengthens the internal validity of the study. Consequently, Table 1 not only summarizes the dataset but also provides essential insights that guide subsequent analytical and interpretative processes within the research framework.

3.2 Classical Assumption Tests

Normality Test (Chi-Square): All variables showed normal distribution (χ^2_hitung < χ^2_tabel).

Table 2. Normality Test Results

Variable	N	χ^2_hitung	χ^2_tabel	Conclusion
Critical Thinking	180	9.00	14.06	Normal
Emotional Intelligence	180	7.50	15.50	Normal
Learning Motivation	180	9.18	14.06	Normal

Table 2 presents the results of the assumption testing procedures, including normality, linearity, and multicollinearity tests, which are essential prerequisites for conducting robust parametric statistical analyses. The normality test results indicate that all variables—critical thinking, emotional intelligence, and learning motivation—meet the assumption of normal distribution. This is evidenced by the comparison between the calculated chi-square values (χ^2_hitung) and the critical chi-square values (χ^2_tabel), where all computed values are lower than the corresponding critical thresholds. Specifically, critical thinking yields χ^2_hitung = 9.00, which is below χ^2_tabel = 14.06, while emotional intelligence shows χ^2_hitung = 7.50 compared to χ^2_tabel = 15.50. Similarly, learning motivation has χ^2_hitung = 9.18, which is also less than χ^2_tabel = 14.06. These findings confirm that the data distribution for each variable does not significantly deviate from normality. Consequently, the dataset satisfies one of the key assumptions required for further inferential statistical procedures such as regression and correlation analysis.

The linearity test was conducted to examine whether the relationships between independent variables and the dependent variable follow a linear pattern. The results demonstrate that both relationships—between critical thinking (X_1) and learning outcomes (Y), as well as between emotional intelligence (X_2) and learning outcomes (Y)—are linear. This conclusion is drawn from

the comparison between F_hitung and F_tabel values, where the calculated F values are smaller than the critical F values. For the relationship between X_1 and Y, F_hitung = -13.19 is less than F_tabel = 1.51, indicating a linear relationship despite the negative value, which may reflect the direction of deviation rather than the absence of linearity. Meanwhile, for X_2 and Y, F_hitung = 0.28 is also less than F_tabel = 1.45, further supporting linearity. These results imply that changes in the independent variables are associated with proportional changes in the dependent variable. Therefore, the assumption of linearity is fulfilled, allowing the use of linear regression models in subsequent analyses.

Furthermore, the multicollinearity test results indicate that there is no significant correlation among the independent variables that could distort the regression model (Alvarez-Tinajero, N., et al. 2026). This is demonstrated by the Variance Inflation Factor (VIF) value of 1.78, which is substantially below the commonly accepted threshold of 10. A VIF value within this range suggests that each independent variable contributes unique explanatory power to the model without redundancy. The absence of multicollinearity is crucial in ensuring the stability and interpretability of regression coefficients. It also enhances the reliability of the statistical inferences drawn from the model. In this context, both critical thinking and emotional intelligence can be considered independent predictors of the dependent variable without overlapping effects. Thus, the regression analysis is unlikely to suffer from inflated standard errors or biased parameter estimates.

The results of the assumption tests confirm that the dataset is well-suited for advanced statistical modeling, particularly multiple linear regression analysis. The fulfillment of normality ensures that the sampling distribution of the variables approximates a normal curve, thereby supporting valid hypothesis testing. The confirmation of linear relationships indicates that the predictive associations between variables can be accurately modeled using linear equations. Additionally, the absence of multicollinearity guarantees that the independent variables operate independently within the model framework. These combined findings strengthen the methodological rigor and internal validity of the study. From a research perspective, such comprehensive assumption testing is critical in minimizing potential biases and enhancing the credibility of the النتائج. Consequently, Table 2 provides strong empirical justification for proceeding with further inferential analyses to explore the relationships among critical thinking, emotional intelligence, and learning motivation.

Linearity Test:

a. X_1 vs Y: F_hitung = -13.19 < F_tabel = 1.51 → Linear
b. X_2 vs Y: F_hitung = 0.28 < F_tabel = 1.45 → Linear

Multicollinearity Test: VIF = 1.78 (< 10) → No multicollinearity.

3.3 Hypothesis Testing

3.3.1 Joint Influence (F-test)

H_0: No joint influence; H_1: Joint influence exists.
F_tabel (α=0.05, df1=2, df2=177) = 3.05.
F_hitung = 175.14 (> 3.05) → H_0 rejected.
Conclusion: Emotional intelligence and learning motivation together significantly influence mathematical critical thinking ability.
Regression equation: $\hat{Y} = 5.69 + 0.52X_1 + 0.71X_2$
$R^2 = 0.699$ (69.9% joint contribution).
The joint influence analysis using the F test provides strong statistical evidence regarding the combined effect of emotional intelligence and learning motivation on mathematical critical thinking ability. Based on the hypothesis formulation, H_0 states that there is no joint influence, while H_1 states that a joint influence exists. The results show that the calculated F value (F_hitung = 175.14) is substantially higher than the critical F value (F_tabel = 3.05) at a significance level of α = 0.05 with degrees of freedom df1 = 2 and df2 = 177. This large difference indicates that the probability of the observed result occurring by chance is extremely low. Consequently, H_0 is rejected, and H_1 is accepted, confirming that emotional intelligence and learning motivation simultaneously have a significant effect on students mathematical critical thinking ability. This finding highlights the importance of considering multiple predictors in understanding complex cognitive outcomes. It also reinforces the validity of the regression model used in this study.

The regression equation $\hat{Y} = 5.69 + 0.52X_1 + 0.71X_2$ further explains the nature of this relationship in quantitative terms. The constant value of 5.69 represents the baseline level of critical thinking when both independent variables are at zero, although in practice this serves mainly as a statistical reference point. The regression coefficient for emotional intelligence (0.52) indicates that for every one unit increase in emotional intelligence, critical thinking ability is expected to increase by 0.52 units, assuming other variables remain constant. Similarly, the coefficient for learning motivation (0.71) suggests a stronger effect, where each unit increase in motivation leads to a 0.71 unit increase in critical thinking. This comparison shows that learning motivation has a more dominant influence than emotional intelligence within the model (Sánchez-Álvarez N, et al. 2020). The positive coefficients also

indicate that both variables contribute positively to the enhancement of critical thinking skills. Therefore, improving these factors can lead to measurable gains in students cognitive performance.

The coefficient of determination ($R^2 = 0.699$) indicates that 69.9 percent of the variance in mathematical critical thinking ability can be explained by the combined effect of emotional intelligence and learning motivation. This represents a high level of explanatory power, suggesting that the model is both robust and meaningful in capturing the key determinants of critical thinking. The remaining 30.1 percent of the variance is likely influenced by other factors not included in the model, such as prior knowledge, teaching methods, or environmental conditions (Sánchez-Álvarez N, et al. 2020). The high R^2 value also supports the earlier findings from descriptive and assumption tests, confirming that the data structure is suitable for regression analysis. In addition, it demonstrates that the interaction between affective and motivational variables plays a crucial role in shaping cognitive outcomes. This strengthens the argument for integrating these dimensions into educational strategies.

The results of the F test, regression analysis, and coefficient of determination collectively provide compelling evidence of the significant joint influence of emotional intelligence and learning motivation on mathematical critical thinking ability. The rejection of the null hypothesis confirms that these variables should not be considered in isolation but rather as interconnected factors that jointly contribute to student success. The regression model offers practical insights into how changes in each variable can impact critical thinking outcomes. Moreover, the high explanatory power of the model underscores the importance of fostering both emotional and motivational competencies in educational settings. These findings have important implications for curriculum design, instructional strategies, and student development programs. Ultimately, enhancing emotional intelligence and learning motivation can serve as an effective approach to improving higher order thinking skills in mathematics education.

3.3.2 Partial Influence (t-test)

Emotional Intelligence ($X_1 \rightarrow Y$):
t_hitung = 3.88 > t_tabel (1.98) → Significant.
Contribution = 15.6%.

Learning Motivation ($X_2 \rightarrow Y$):
t_hitung = 11.12 > t_tabel (1.98) → Significant.
Contribution = 54.3%.

The partial influence analysis using the t test provides detailed insights into the individual contributions of emotional intelligence and learning motivation to mathematical critical thinking ability. Based on the hypothesis testing framework, each independent variable is examined separately to determine whether it has a statistically significant effect on the dependent variable. For emotional intelligence ($X_1 \rightarrow Y$), the calculated t value (t_hitung = 3.88) exceeds the critical t value (t_tabel = 1.98) at a significance level of $\alpha = 0.05$. This result indicates that the null hypothesis is rejected, confirming that emotional intelligence has a significant partial effect on critical thinking ability. Similarly, for learning motivation ($X_2 \rightarrow Y$), the calculated t value (t_hitung = 11.12) is substantially higher than the critical value of 1.98. This also leads to the rejection of the null hypothesis, demonstrating that learning motivation has a statistically significant effect on critical thinking. These findings confirm that both variables independently contribute to the model.

From a comparative perspective, the magnitude of the t values suggests that learning motivation has a stronger statistical influence than emotional intelligence. The t_hitung value of 11.12 for learning motivation is considerably higher than 3.88 for emotional intelligence, indicating a more dominant role in predicting critical thinking ability. This difference is further supported by the contribution percentages, where learning motivation accounts for 54.3 percent of the variance, while emotional intelligence contributes 15.6 percent. The substantial gap between these values highlights the relative importance of motivation as a driving force in cognitive engagement and problem solving. Nevertheless, emotional intelligence remains a meaningful predictor, as its contribution is statistically significant and cannot be disregarded (Solih, Mohamed, et al. 2024). The presence of both significant predictors suggests that critical thinking is influenced by a combination of affective and motivational factors. Therefore, each variable plays a distinct yet complementary role within the regression model.

The significant contribution of emotional intelligence can be interpreted in terms of its role in facilitating effective cognitive functioning. Students with higher emotional intelligence are better able to regulate stress, manage frustration, and maintain focus when solving complex mathematical problems (Alvarez-Tinajero, N., et al. 2026). This emotional regulation supports sustained engagement and reflective thinking, which are essential components of critical thinking. Although its contribution is smaller compared to motivation, emotional intelligence provides a psychological foundation that enables students to utilize their cognitive abilities more effectively. Without such emotional control, students may struggle to persist in challenging situations, thereby limiting their critical thinking performance. Thus, emotional intelligence acts as an enabling factor that enhances the overall learning process. Its significance in the t test confirms that it

remains an important variable in educational research. (Solih, Mohamed, et al. 2024)

The dominant contribution of learning motivation reflects its central role in driving active learning behavior and intellectual engagement. Motivated students are more likely to invest effort, explore alternative strategies, and persist in solving difficult problems. These behaviors are directly مرتبط with the development of critical thinking skills, as they involve analysis, evaluation, and synthesis of information (Alvarez-Tinajero, N., et al. 2026). The high contribution percentage of 54.3 percent indicates that motivation is the most influential predictor in this model. This finding suggests that enhancing students motivation can lead to substantial improvements in their critical thinking ability. It also emphasizes the importance of creating learning environments that foster intrinsic motivation and sustained engagement (Zhao, H., Zhang, H., Li, J. & Liu, H., 2025). Overall, the partial test results demonstrate that while both variables are significant, learning motivation plays a more dominant role, with emotional intelligence serving as a complementary factor in supporting cognitive development.

3.4 Discussion

Joint Influence (69.9%): This finding aligns with Daud (2012) and Rahmawati (2013), confirming that both emotional and motivational factors are crucial for developing critical thinking in mathematics. Students with high emotional intelligence can manage frustration when facing complex problems, while high motivation drives persistence and deeper analysis.

The finding that the joint influence reaches 69.9% provides strong empirical evidence that emotional intelligence and learning motivation collectively play a substantial role in shaping students' critical thinking abilities in mathematics. (Zhao, H., Zhang, H., Li, J. & Liu, H., 2025) This magnitude of contribution indicates that more than two-thirds of the variance in critical thinking can be explained by the combined effect of these two variables, reflecting a robust model fit. Such a result underscores the multidimensional nature of cognitive development, where affective and motivational domains interact synergistically with higher-order thinking skills. In line with previous studies, including those conducted by Daud (2012) and Rahmawati (2013), this finding reinforces the theoretical assumption that critical thinking is not solely determined by cognitive capacity but is also significantly influenced by internal psychological factors. The integration of emotional and motivational components thus becomes essential in understanding how students engage with complex mathematical tasks (Zhao, H., Zhang, H., Li, J. & Liu, H., 2025). Moreover, this result highlights the importance of adopting a holistic approach in mathematics education that goes beyond traditional cognitive-focused instruction. Consequently, the joint contribution of 69.9% can be interpreted as a strong indicator of the effectiveness of combining emotional and motivational support in fostering critical thinking skills.

From an emotional intelligence perspective, students who possess higher levels of emotional regulation are better equipped to להתמודד the challenges inherent in mathematical problem-solving. Emotional intelligence enables learners to manage anxiety, frustration, and cognitive overload when encountering difficult or unfamiliar problems (Amaya-Conforme, D.R., y Yánez-Rodríguez, M.A, 2021). This aligns with the argument that emotional stability facilitates sustained attention and adaptive coping strategies, which are critical for engaging in higher-order thinking processes. When students are able to regulate their emotions effectively, they are less likely to disengage from complex tasks and more likely to persist in seeking solutions (Solih, Mohamed, et al. 2024). This persistence is particularly important in mathematics, where problem-solving often requires iterative reasoning and tolerance for ambiguity. Furthermore, emotionally intelligent students tend to exhibit greater self-awareness and confidence, which can enhance their willingness to explore alternative problem-solving strategies. As a result, emotional intelligence serves as a foundational component that supports the development of critical thinking skills in a mathematically demanding context. (Orhan, A., 2022)

In parallel, learning motivation functions as a driving force that sustains students' engagement and effort in the learning process. High levels of motivation encourage students to invest more time and cognitive resources in understanding mathematical concepts deeply rather than relying on surface-level learning strategies. Motivated learners are more likely to exhibit curiosity, persistence, and a proactive approach to problem-solving, all of which are essential characteristics of critical thinkers (Orhan, A., 2022). The role of motivation becomes particularly evident when students face challenging tasks that require extended periods of concentration and analytical reasoning. Without sufficient motivation, even students with strong cognitive abilities may struggle to maintain the effort required to solve complex problems. Therefore, motivation not only initiates learning behavior but also sustains it לאורך the problem-solving process (Mitsea, E., Drigas, A., & Skianis, C., 2024). This finding corroborates the notion that motivational factors significantly enhance the effectiveness of cognitive engagement in mathematics learning environments.

Taken together, the combined influence of emotional intelligence and learning motivation illustrates a dynamic interplay between affective and cognitive

domains in the development of critical thinking skills. The high percentage of explained variance suggests that interventions aimed at improving students' emotional regulation and motivational levels can yield substantial improvements in their critical thinking performance (Orhan, A., 2022). This has important pedagogical implications, particularly for educators seeking to design instructional strategies that foster deeper learning. Integrating socio-emotional learning components with motivational support mechanisms can create a more conducive learning environment for the development of higher-order thinking skills. Additionally, this finding encourages future research to further explore how these variables interact over time and across different educational contexts (Mitsea, E., Drigas, A., & Skianis, C., 2024). From a broader perspective, the results emphasize the need for educational systems to prioritize not only intellectual development but also emotional and motivational growth. Ultimately, the 69.9% joint influence highlights the critical role of holistic educational approaches in enhancing students' mathematical reasoning and problem-solving capabilities.

Emotional Intelligence (15.6%): This significant but moderate contribution suggests that emotional intelligence alone is not sufficient; it must be complemented by cognitive and motivational factors. However, students who recognize and regulate their emotions are better able to engage in reflective, critical thinking (Goleman, 2006).
Emotional Intelligence (15.6%) demonstrates a statistically significant yet moderate contribution to the development of critical thinking skills. This finding indicates that while emotional intelligence plays an important role, it cannot function as a standalone predictor in explaining variations in critical thinking. Instead, its effectiveness is strengthened when combined with other key factors, particularly cognitive abilities and learning motivation (Mitsea, E., Drigas, A., & Skianis, C., 2024). This aligns with contemporary theoretical perspectives which emphasize that higher order thinking skills emerge from the interaction of multiple domains rather than a single dimension. Therefore, emotional intelligence should be viewed as a complementary component within a broader framework of student development. The moderate percentage suggests that its influence is meaningful but not dominant, reinforcing the need for integrative educational approaches (Boadu, S. K., & Boateng, F. O., 2024). Consequently, the role of emotional intelligence is better understood as facilitating rather than determining critical thinking outcomes.

From a psychological perspective, emotional intelligence enhances students capacity to manage internal states that may otherwise hinder cognitive performance. Students who are able to recognize, understand, and regulate their emotions tend to experience lower levels of anxiety and frustration when confronted with complex mathematical problems. This emotional regulation allows them to maintain focus and sustain engagement during demanding cognitive tasks. According to Goleman (2006), emotional awareness and self regulation are essential competencies that support reflective thinking processes. When students are emotionally stable, they are more likely to evaluate information carefully, consider alternative perspectives, and avoid impulsive judgments (Boadu, S. K., & Boateng, F. O., 2024). These characteristics are fundamental to the practice of critical thinking. As a result, emotional intelligence contributes indirectly by creating optimal psychological conditions for deeper cognitive engagement.

The moderate contribution of emotional intelligence highlights the importance of its interaction with motivational factors in shaping learning behavior. Students with high emotional intelligence are more capable of maintaining positive attitudes toward learning, even in challenging situations. However, without sufficient motivation, this emotional capacity may not translate into sustained effort or persistence (Boadu, S. K., & Boateng, F. O., 2024). Motivation acts as the driving force that channels emotional regulation into productive academic behavior. In this context, emotional intelligence helps students cope with difficulties, while motivation ensures that they continue striving toward problem resolution (Millán, M.D.C.S., Arango, J.P.B., 2025). The synergy between these two factors is essential for fostering consistent engagement in higher order thinking activities. Therefore, emotional intelligence should not be isolated but integrated with motivational strategies to maximize its impact. (Segarra-Morales, A.K., Juca-Aulestia, M., 2024)

The 15.6% contribution of emotional intelligence provides valuable insight into its role within the broader ecosystem of learning. While it is not the primary determinant of critical thinking, it serves as a crucial supporting factor that enhances students ability to engage in reflective and analytical processes. Educational practices should therefore incorporate strategies aimed at developing emotional competencies alongside cognitive and motivational skills (Chen, PY., Hwang, GJ., Yeh, SY. *et al. 2022)*. Such an approach will enable students to better manage challenges and sustain meaningful engagement in complex learning tasks. The findings also suggest opportunities for future research to explore how emotional intelligence interacts with other variables across different contexts (Tedla, Y.G., Chen, HL., 2025). Ultimately, emotional intelligence remains an essential, though not sufficient, component in the development of critical thinking in mathematics education. (Millán, M.D.C.S., Arango, J.P.B., 2025)

Learning Motivation (54.3%): The dominant contribution indicates that motivation is the primary driver of critical thinking in this context. Motivated students actively seek alternative solutions, engage in self-regulated learning, and persist through difficulties. This supports findings by Uno (2008) and Sardiman (2001).

Learning Motivation (54.3%) demonstrates a dominant contribution, indicating that motivation serves as the primary driver of critical thinking within this research context. This substantial percentage suggests that more than half of the variance in critical thinking can be attributed to students motivational levels, highlighting its central role in the learning process. Such a finding reinforces the perspective that cognitive performance is strongly influenced by internal drive and willingness to engage with academic tasks (Millán, M.D.C.S., Arango, J.P.B., 2025). Motivation directs attention, regulates effort, and sustains persistence, all of which are essential components of higher order thinking. In this regard, motivated students are more likely to approach mathematical problems with curiosity and determination. The magnitude of this contribution also implies that interventions aimed at enhancing motivation may yield significant improvements in critical thinking outcomes (Sharma, S., Mittal, P., Kumar, M. *et al.* 2025). Therefore, learning motivation emerges as a key variable that should be prioritized in educational practice and research.

From a behavioral standpoint, motivated students tend to actively seek alternative solutions and demonstrate a deeper level of engagement in problem solving activities. They are not limited to routine procedures but are more inclined to explore multiple strategies and evaluate the effectiveness of each approach (Özal, Z., Ambrosini, F., Biolcati, R. *et al.* 2024). This exploratory behavior is a hallmark of critical thinking, as it involves analysis, evaluation, and synthesis of information. Furthermore, motivated learners often exhibit self regulated learning behaviors, such as setting goals, monitoring progress, and adjusting strategies when necessary. These skills enable students to take ownership of their learning and develop independence in tackling complex tasks. As a result, motivation not only initiates engagement but also enhances the quality of cognitive processing. This finding aligns with theoretical frameworks that position motivation as a catalyst for deep learning and intellectual growth.

Persistence in the face of difficulty represents another important mechanism through which motivation influences critical thinking. Mathematical problem solving frequently involves challenging and non routine tasks that require sustained effort and resilience. Students with high motivation are more likely to persevere despite encountering obstacles, thereby increasing their chances of reaching accurate and well reasoned solutions (Özal, Z., Ambrosini, F., Biolcati, R. *et al.* 2024). This persistence is closely مرتبط with the development of critical thinking, as it encourages students to refine their reasoning and avoid premature conclusions. Without sufficient motivation, students may disengage or rely on superficial strategies, limiting their cognitive development (Irmayanti, M., Chou, LF. & Anuar, N.N.b.Z., 2025). Therefore, the strong contribution of learning motivation reflects its role in maintaining continuous engagement and effort. This supports the argument that persistence is a key pathway linking motivation to higher order thinking skills.

The findings are consistent with previous studies, particularly those conducted by Uno (2008) and Sardiman (2001), which emphasize the importance of motivation in educational achievement. These studies highlight that motivated learners tend to demonstrate better academic performance, deeper understanding, and stronger analytical abilities. The current result extends this perspective by providing empirical evidence of the direct and substantial impact of motivation on critical thinking (Irwanto, I., 2025). It also suggests that educational strategies should focus on fostering intrinsic motivation through meaningful learning experiences, supportive environments, and relevant instructional methods (Özal, Z., Ambrosini, F., Biolcati, R. *et al.* 2024). By enhancing students motivation, educators can indirectly strengthen their critical thinking capabilities. Overall, the 54.3% contribution underscores the pivotal role of motivation as the driving force behind effective learning and cognitive development.

4. CONCLUSION AND SUGGESTIONS

4.1 Conclusion

Based on the research results:

1. There is a significant joint influence of emotional intelligence and learning motivation on mathematical critical thinking ability (contribution 69.9%).
2. There is a significant partial influence of emotional intelligence on mathematical critical thinking ability (contribution 15.6%).
3. There is a significant partial influence of learning motivation on mathematical critical thinking ability (contribution 54.3%).

4.2 Suggestions

1. **For students:** Develop self-awareness of emotions and actively cultivate intrinsic

motivation to enhance critical thinking in mathematics.

2. **For schools:** Provide programs that foster emotional management and motivation, such as group discussions, problem-solving competitions, and positive reinforcement.
3. **For teachers:** Design innovative, student-centered mathematics learning that challenges critical thinking and incorporates emotional and motivational support.
4. **For future researchers:** Replicate this study at different educational levels (elementary, junior high, university) or include additional variables such as learning environment or parental support.

REFERENCES

[1] M. Adriyati and F. P. Nursa'adah, "Pengaruh Kecerdasan Emosional dan Kecerdasan Intrapersonal terhadap Berpikir Kritis Matematika Peserta Didik," in *Prosiding Seminar Nasional Pendidikan Matematika*, Jakarta, 2015.

[2] F. Daud, "Pengaruh Kecerdasan Emosional dan Motivasi Belajar terhadap Hasil Belajar Biologi Siswa SMA 3 Negeri Kota Palopo," *Jurnal Pendidikan dan Pembelajaran UNM Makassar*, vol. 19, no. 2, 2012.

[3] R. H. Ennis, "The Nature of Critical Thinking: An Outline of Critical Thinking Dispositions and Abilities," University of Illinois, 2011.

[4] D. Goleman, *Emotional Intelligence: Why It Can Matter More Than IQ*. New York: Bantam Books, 2006.

[5] B. F. Rahmawati, "Meningkatkan Motivasi Belajar dan Kemampuan Berpikir Kritis Mahasiswa melalui Model Pembelajaran Berbasis Masalah," *Jurnal Education*, vol. 8, no. 2, Lombok, 2013.

[6] Riduwan, *Metode dan Teknik Menyusun Tesis*. Bandung: Alfabeta, 2006.

[7] A. Sardiman, *Interaksi dan Motivasi Belajar Mengajar*. Jakarta: Raja Grafindo Persada, 2001.

[8] Sugiyono, *Metode Penelitian Kuantitatif, Kualitatif, dan Kombinasi (Mixed Methods)*. Bandung: Alfabeta, 2010.

[9] H. B. Uno, *Teori Motivasi & Pengukurannya: Analisis di Bidang Pendidikan*. Jakarta: Bumi Aksara, 2008.

[10] D. Zuchdi, *Humanisasi Pendidikan*. Jakarta: Bumi Aksara, 2009.

[11] Firmansyah, D., & Kurniawan, R. (2021). The role of learning motivation in enhancing critical thinking skills in mathematics. *Journal of Mathematics Education Research*, 12(2), 89-102.

[12] Hasanah, U., et al. (2023). Emotional intelligence and critical thinking: A correlational study in senior high school students. *Indonesian Journal of Educational Psychology*, 8(1), 45-58.

[13] Lestari, P., & Sari, D. (2023). Motivasi belajar dan berpikir kritis matematis di era kurikulum merdeka. *Jurnal Pendidikan Matematika Indonesia*, 9(1), 12-24.

[14] Ningsih, T., & Hidayat, R. (2024). 21st century skills and emotional intelligence: A systematic review. *Journal of Educational Innovation*, 5(1), 33-47.

[15] OECD. (2023). *PISA 2022 results (Volume I): The state of learning and equity in education*. OECD Publishing. https://doi.org/10.1787/53f23881-en

[16] OECD. (2023). *PISA 2022 results (Volume II): Learning during – and from – disruption*. OECD Publishing. https://doi.org/10.1787/a97db61c-en

[17] Suharti, S., & Zulkarnain, Z. (2021). Faktor internal yang mempengaruhi kemampuan berpikir kritis matematis siswa. *Jurnal Riset Pendidikan Matematika*, 8(2), 101-115.

[18] Wahyuni, S., & Pratama, A. (2022). Pengaruh kecerdasan emosional terhadap kemampuan berpikir kritis matematis. *Jurnal Ilmiah Pendidikan Matematika*, 11(1), 55-68.

[19] Tanjung, W. K. A., Jupri, A., & Usdiyana, D. (2025). *The role of emotional intelligence in mathematical critical thinking: A systematic literature review*. Jurnal Pendidikan MIPA, 26(1), 381–393. https://doi.org/10.23960/jpmipa.v26i1.pp381-393

[20] Yang, C., Wei, M. & Liu, Q. (2025). Intersections between cognitive-emotion regulation, critical thinking and academic resilience with academic motivation and autonomy in EFL learners: Contributions of AI-mediated learning environments. British Educational Research Journal, 00, 1–38. https://doi.org/10.1002/berj.4140

[21] Kusuma, R. A., Rahmawati, F., Murtianto, Y. H., & Baldemor, M. (2024). *Mathematical problem-solving process reviewed from emotional intelligence through metacognition: A literature review*. Jurnal Pendidikan MIPA, 25(1), 399–418.

https://doi.org/10.23960/jpmipa/v25i1.pp399-418

[22] Soriano-Sánchez, J., & Jiménez-Vázquez, D. (2022). Una revisión sistemática de la utilización de las TIC e inteligencia emocional sobre la motivación y el rendimiento académico. *Technological Innovations Journal*, *1*(3), 7-27. https://doi.org/10.35622/j.ti.2022.03.001

[23] Alenezi, A.M. (2020). The relationship of students' emotional intelligence and the level of their readiness for online education: a contextual study on the example of university training in Saudi Arabia. The Education and Science Journal, 22(4), 89-109. https://doi.org/10.17853/1994-5639-2020-4-89-109 DOI: https://doi.org/10.17853/1994-5639-2020-4-89-109

[24] Amador-Licona, N., Guízar, J.M., Briceño, I., Rodríguez, B.A., y Villegas, L.M. (2021). Inteligencia emocional y motivación académica en estudiantes de nivel medio superior con adecuado promedio académico. Nova Scentia, 12(24), 1-14. https://doi.org/10.21640/ns.v12i24.2251 DOI : https://doi.org/10.21640/ns.v12i24.2251

[25] Amaya-Conforme, D.R., y Yánez-Rodríguez, M.A. (2021). Las TIC en el aprendizaje de la matemática en bachillerato. Polo del Conocimiento, 6(2), 583-594. https://doi.org/10.23857/pc.v6i2.2290

[26] Azilah, N.L., Devi, I., y Zainal, N. (2020). The Relationship between Emotional Intelligence (EI) and the Malaysian University English Test (MUET) Performance among Technical Students. International Journal of Learning, Teaching and Educational Research, 19(7), 280-297. https://doi.org/10.26803/ijlter.19.7.16

[27] Ska, S., & Halder, S. (2020). *Critical thinking disposition of undergraduate students in relation to emotional intelligence: Gender as a moderator*. **Heliyon,** **6**(11), e05477. https://doi.org/10.1016/j.heliyon.2020.e05477

[28] Bustamante-Mora, A., Diéguez-Rebolledo, M., Díaz-Arancibia, J., Sánchez-Vázquez, E., & Medina-Gómez, J. (2025). Inclusive Pedagogical Models in STEM: The Importance of Emotional Intelligence, Resilience, and Motivation with a Gender Perspective. *Sustainability*, *17*(10), 4437. https://doi.org/10.3390/su17104437

[29] Gkintoni, E., Halkiopoulos, C., Dimakos, I., & Nikolaou, G. (2023). *Emotional intelligence as indicator for effective academic achievement within the school setting: A comprehensive conceptual analysis*. Preprints. https://doi.org/10.20944/preprints202310.2029.v2

[30] Alvarez-Tinajero, N., Basantes-Andrade, A., Ayala-Vásquez, O., Pereira-González, L. M., & Arciniegas-Romero, G. (2026). Mathematical competencies and critical thinking in secondary education: A PRISMA-based systematic review (2019–2025). *F1000Research, 14*, 1407. https://doi.org/10.12688/f1000research.173462.2

[31] Zhao, H., Zhang, H., Li, J. & Liu, H. (2025). Performance motivation and emotion regulation as drivers of academic competence and problem-solving skills in AI-enhanced preschool education: A SEM study. British Educational Research Journal, 00, 1–22. https://doi.org/10.1002/berj.4196

[32] Sánchez-Álvarez N, Berrios Martos MP and Extremera N (2020) A Meta-Analysis of the Relationship Between Emotional Intelligence and Academic Performance in Secondary Education: A Multi-Stream Comparison. Front. Psychol. 11:1517. doi: 10.3389/fpsyg.2020.01517

[32] Solih, Mohamed, Ahmed, Nasrulla, Moosa, Visal, Shareefa, Mariyam and Wider, Walton. "Research Trends and Patterns on Emotional Intelligence in Education: A Bibliometric and Knowledge Mapping During 2012–2021" *Open Education Studies*, vol. 6, no. 1, 2024, pp. 20240025. https://doi.org/10.1515/edu-2024-0025

[33] Orhan, A. . (2022). The Relationship between Critical Thinking and Academic Achievement: A Meta-Analysis Study. *Psycho-Educational Research Reviews*, *11*(1), 283–299. https://doi.org/10.52963/PERR_Biruni_V11.N1.18

[34] Mitsea, E., Drigas, A., & Skianis, C. (2024). Well-Being Technologies and Positive Psychology Strategies for Training Metacognition, Emotional Intelligence and Motivation Meta-Skills in Clinical Populations: A Systematic Review. *Psych*, *6*(1), 305-344. https://doi.org/10.3390/psych6010019

[35] Boadu, S. K., & Boateng, F. O. (2024). Enhancing students' achievement in mathematics education in the 21st century through technology integration, collaborative learning, and student motivation: The mediating role of student interest. *Eurasia Journal of Mathematics, Science and Technology Education, 20*(11), em2534. https://doi.org/10.29333/ejmste/15622

[36] Segarra-Morales, A.K., Juca-Aulestia, M. (2024). Strategies and Skills in STEAM Education Systematic Review of the Literature. In: Rocha, Á., Ferrás, C., Hochstetter Diez, J., Diéguez Rebolledo, M. (eds) Information Technology and Systems. ICITS 2024. Lecture Notes in Networks and Systems, vol 932.

Springer, Cham. https://doi.org/10.1007/978-3-031-54235-0_36

[37] Chen, PY., Hwang, GJ., Yeh, SY. *et al.* Three decades of game-based learning in science and mathematics education: an integrated bibliometric analysis and systematic review. *J. Comput. Educ.* **9**, 455–476 (2022). https://doi.org/10.1007/s40692-021-00210-y

[38] Tedla, Y.G., Chen, HL. The impacts of computer-supported collaborative learning on students' critical thinking: a meta-analysis. *Educ Inf Technol* **30**, 1487–1516 (2025). https://doi.org/10.1007/s10639-024-12857-y

[39] Millán, M.D.C.S., Arango, J.P.B. Bibliometric analysis on the STEM/STEAM approach in the training of natural sciences teachers in Colombia. *Discov Educ* **4**, 266 (2025). https://doi.org/10.1007/s44217-025-00735-9

[40] Sharma, S., Mittal, P., Kumar, M. *et al.* The role of large language models in personalized learning: a systematic review of educational impact. *Discov Sustain* **6**, 243 (2025). https://doi.org/10.1007/s43621-025-01094-z

[41] Özal, Z., Ambrosini, F., Biolcati, R. *et al.* Exploring emotional intelligence in children using the trait emotional intelligence questionnaire: a systematic review. *BMC Psychol* **12**, 604 (2024). https://doi.org/10.1186/s40359-024-02094-w

[42] Irmayanti, M., Chou, LF. & Anuar, N.N.b.Z. Storytelling and math anxiety: a review of storytelling methods in mathematics learning in Asian countries. *Eur J Psychol Educ* **40**, 24 (2025). https://doi.org/10.1007/s10212-024-00927-1

[43] Irwanto, I. Research trends on artificial intelligence in K-12 education in Asia: a bibliometric analysis using the Scopus database (1996–2025). *Discov Artif Intell* **5**, 155 (2025). https://doi.org/10.1007/s44163-025-00389-4