



# The effects of logical–mathematical intelligence and growth mindset on students’ numeracy and academic achievement

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## Abstract

Numeracy skills and academic achievement are key indicators of student educational success and are influenced by both cognitive and non-cognitive factors. However, previous studies have often examined logical–mathematical intelligence and a growth mindset separately, so empirical evidence on their combined role in influencing numeracy skills and academic achievement remains limited. Therefore, this study investigates the influence of logical–mathematical intelligence and growth mindset, both independently and interactively, on students’ numeracy skills and academic achievement. This study employed an exploratory quantitative factorial design using a two-way Multivariate Analysis of Variance (MANOVA) approach, involving a small sample of 30 ninth-grade students from a public junior high school in Jepara, Indonesia, which requires cautious interpretation of the findings. The results indicate that logical–mathematical intelligence has a significant effect on students’ numeracy skills ( $p < .001$ ), while growth mindset significantly affects students’ academic achievement ( $p = .02$ ). However, there is no significant interaction between logical–mathematical intelligence and growth mindset on both dependent variables ( $p = .937$ ). Based on the results, these findings indicate that logical–mathematical intelligence and growth mindset are independently associated with different learning outcomes, rather than exerting a combined or interactive effect.

**Keywords:** academic achievement; growth mindset; logical-mathematical intelligence; numeracy skills

**How to cite:** Munzayanah, N., Usodo, B., Fitriana, L., & Pramesti, G. (2026). The effects of logical–mathematical intelligence and growth mindset on students’ numeracy and academic achievement. *Jurnal Elemen*, 12(1), 110-123. <https://doi.org/10.29408/jel.v12i1.32476>

Received: 1 October 2025 | Revised: 22 December 2025

Accepted: 20 January 2026 | Published: 19 February 2026



## Introduction

Education at the junior high school level plays an important role in developing basic skills and mindsets that lay the foundation for students' academic success. The process of education involves more than just imparting knowledge, it also involves helping students develop critical thinking skills and positive attitudes. Numeracy, which enables students to understand, interpret, and apply numerical information in academic and real-life contexts, is one of the important competencies that need to be developed. The Organization for Economic Cooperation and Development (OECD, 2019) defines numeracy as the ability to formulate, apply, and interpret mathematics in various real-world contexts through reasoning with concepts, procedures, facts, and tools to describe, explain, and predict phenomena. Numeracy skills are crucial to acquire because they help students to solve problems, make decisions, and actively participate in a variety of subjects like science, economics, and technology.

Despite its importance, several international assessments continue to show significant challenges in developing students' numeracy skills in various contexts. However, based on the results of the 2022 Program for International Student Assessment (PISA), Indonesia's average mathematics score decreased from 379 in 2018 to 366 in 2022, placing it below the OECD average (OECD, 2023). This decline indicates that existing learning processes and educational interventions have not optimally strengthened students' numeracy skills. These findings highlight the urgency of analyzing the fundamental factors that shape the development of students' numeracy skills and overall academic outcomes, particularly in the cognitive and non-cognitive dimensions of learning.

Low numeracy skills have a direct impact on students' academic performance, especially in subjects that require a strong understanding of mathematics (Simanungkalit et al., 2022). This condition shows that difficulties in numeracy are closely related to broader academic challenges, making it important to investigate the factors that contribute to students' numeracy skills. Numeracy enables students to think critically, solve problems, and apply mathematical concepts in various contexts, which ultimately supports academic achievement (OECD, 2019). Without good numeracy skills, students are likely to experience difficulties in understanding advanced concepts, which ultimately affects their overall academic outcomes.

Students' numeracy skills can be predicted through the type of intelligence that develops in students (Rahbarnia et al., 2014). According to Gardner's theory of multiple intelligences, logical-mathematical intelligence is one of the main intelligences emphasized in formal education (Syarifah, 2019). Logical-mathematical intelligence refers to the ability to reason logically, recognize numerical patterns, and solve problems using abstract and symbolic thinking, all of which are important foundations in numeracy learning. Given this close relationship, logical-mathematical intelligence is considered a key cognitive factor that influences students' numeracy skills (Milati et al., 2023). However, cognitive abilities alone may not be sufficient to explain differences in students' numeracy skills and academic achievement, as students with similar intellectual capacities may exhibit different levels of perseverance, motivation, and learning outcomes (OECD, 2019). In addition to intellectual

ability, students' belief in their own abilities plays an important role in the academic process. Dweck (2006) introduced the concept of a growth mindset, which represents a belief that abilities can be developed through effort, strategic approaches, and resilience. Students with a growth mindset are more likely to embrace challenges, remain steadfast during difficulties, and view failure as a crucial part of the learning process (Yeager & Dweck, 2020). Additional meta-analytic research indicates that a development mindset correlates with academic outcomes, however, the effects generally not very significant and highly dependent on contextual and individual factors (Sisk et al., 2018). This characteristic is relevant in numeracy learning, as it often requires persistent effort and resilience when confronted with complex or unfamiliar mathematical challenges. So, a growth mindset is expected to contribute not only to numeracy skills but also to students' overall academic achievement.

Previous studies have shown that logical-mathematical intelligence plays an important role in students' numeracy development (Milati et al., 2023; Anugrah, 2024), with evidence showing that students with higher levels of logical-mathematical intelligence are better able to analyze problems, connect relevant information, and apply appropriate problem-solving strategies in numeracy tasks (Fauzi et al., 2023). In addition to cognitive factors, non-cognitive characteristics such as growth mindset have also been found to be related to student learning outcomes. Empirical research shows that students' numeracy skills and academic outcomes are significantly related to growth mindset, although the strength of this relationship is often less significant (Wijaya, 2023), and that students with a growth mindset tend to exhibit higher motivation, perseverance, and more positive academic behavior (Putri & Wilman, 2023; Nasril, 2023). However, recent evidence from different countries indicates that the effect of a growth mindset is not consistent among all students and operates in a more complex manner than often perceived. Svensen (2025) found that growth mindset tends to have a stronger influence on low-achieving students, but its impact is weaker on high-achieving students. Meanwhile, Altikulaç et al. (2024) posited that students with similar growth mindset beliefs can still differ significantly in terms of motivation profiles and academic achievements. Overall, these results show that students' numeracy skills and academic achievement are affected by the interaction between cognitive and affective factors, not just one component on its own.

Recent studies increasingly underscore the necessity for a comprehensive approach to explore how many learning characteristics together influence academic achievements (Altikulaç et al., 2024; Zhang & He, 2025). However, empirical studies that examine the synergistic influence of cognitive factors associated with intelligence and growth mindset within a singular analytical framework are notably limited, especially at the junior high school level. This gap is particularly pronounced in studies that simultaneously consider students' numeracy skills and academic achievement as related but separate educational outcomes.

In response to this gap, his study explores the effect of logical-mathematical intelligence and growth mindset on students' numeracy skills and academic achievement through a multivariate analytical method. This study focuses on junior high school students, adding to a relatively unexplored educational context in the literature. Through this approach, the study seeks to provide a more comprehensive understanding of how cognitive and non-cognitive

factors relate to students' learning outcomes and to offer empirical evidence that may inform more adaptive.

## Methods

This study uses quantitative methods with the two-way MANOVA (Multivariate Analysis of Variance) Test, which aims to examine the effect of independent variables with categorical scales on several dependent variables at once with quantitative data scales (Ghozali, 2009). The main objective of this study is to understand the effect of logical-mathematical intelligence and growth mindset on students' numeracy skills and academic achievement at the junior high school level. The population in this study consisted of ninth-grade students from a public junior high school in Jepara, Central Java, Indonesia, who had studied the topic of congruence. The sample consisted of 30 students selected randomly by stratification to ensure proportional representation of students based on academic ability or class group. Although the sample size ( $n = 30$ ) was relatively small for MANOVA, this study was designed as an exploratory study. Therefore, the results of this study were interpreted with caution, especially regarding statistical power and generalization of results.

The instruments used in this study consisted of four types of instruments. First, student numeracy level data was obtained through a standardized numeracy test adapted from the National Minimum Competency Assessment questions (Kemendikbudristek, 2021). The test used are questions related to the material of congruency in a personal context that is relevant to everyday life so that students can apply numeracy concepts in solving real-world problems. Each essay question was intended to elicit open-ended answers from students, in which they were expected to explain in detail the steps they took to solve the numeracy problems. Second, the instrument used is a logical-mathematical intelligence test. The logical-mathematical intelligence test used in this study was adapted from Rosamina's Logical-Mathematical Intelligence Test (2022), which was developed based on the logical-mathematical intelligence instrument indicators created by Chatib (2012). This test consists of 15 questions that measure four main aspects of logical-mathematical intelligence, namely numerical ability, algebraic concepts, number sequences/patterns, and logic or reasoning. The third measurement tool is a student growth mindset questionnaire, which is a measurement tool developed by Carol Dweck (2006) and has been translated into Indonesian. This questionnaire consists of 20 statements used to measure students' beliefs about their ability to develop and persevere in the face of academic challenges. This questionnaire uses a 4-point Likert scale consisting of Strongly Agree (SS), Agree (S), Disagree (TS), and Strongly Disagree (STS). These second and third instruments were distributed via Google Form to make it easier for students to access them and speed up data collection. Fourth, students' academic achievement was measured using the average midterm examination score, which reflects students' academic performance during the semester.

Prior to data analysis, the reliability of the logical–mathematical intelligence test and the growth mindset questionnaire was evaluated using Cronbach's alpha. The results indicated

acceptable internal consistency for both instruments ( $\alpha$  logical–mathematical intelligence = .83;  $\alpha$  growth mindset = .73), indicating that the instruments were suitable for research purposes.

Data obtained from numeracy tests, logical-mathematical intelligence tests, growth mindset questionnaires, and academic achievement records were analyzed using two-way MANOVA analysis. This analysis aimed to examine how logical-mathematical intelligence and growth mindset simultaneously influence numeracy skills and academic achievement. MANOVA was chosen because it can identify the interaction of independent variables on two dependent variables, as well as determine which variables have a significant effect. This study used a  $2 \times 2$  multivariate factorial design or two-way MANOVA design with four research variables, namely two dependent variables and two independent variables. The dependent variables used were students' numeracy skills (Y1) and academic achievement (Y2), while the independent variables used were students' logical-mathematical intelligence (B) and growth mindset (A).

Logical-mathematical intelligence (LMI) is divided into High LMI (B1), Medium LMI (B2), and Low LMI (B3). While growth mindset is divided into High Growth Mindset (A1) and Low Growth Mindset (A2). The categorization of high, medium, and low levels for both logical–mathematical intelligence and growth mindset was based on the mean and standard deviation approach (mean  $\pm$  1 SD), where scores above (mean + 1 SD) were classified as high, scores between (mean – 1 SD) and (mean + 1 SD) as medium, and scores below (mean – 1 SD) as low. This procedure is commonly used in educational research to ensure objective group classification.

**Table 1.** 2 x 2 Multivariate data processing design

Logical-mathematical Intelligence	Growth Mindset			
	High (A1)		Low (A2)	
	Y <sub>1</sub>	Y <sub>2</sub>	Y <sub>1</sub>	Y <sub>2</sub>
High (B <sub>1</sub> )	Y <sub>1</sub> A <sub>1</sub> B <sub>1</sub>	Y <sub>2</sub> A <sub>1</sub> B <sub>1</sub>	Y <sub>1</sub> A <sub>2</sub> B <sub>1</sub>	Y <sub>2</sub> A <sub>2</sub> B <sub>1</sub>
Medium (B <sub>2</sub> )	Y <sub>1</sub> A <sub>1</sub> B <sub>2</sub>	Y <sub>2</sub> A <sub>1</sub> B <sub>2</sub>	Y <sub>1</sub> A <sub>2</sub> B <sub>2</sub>	Y <sub>2</sub> A <sub>2</sub> B <sub>2</sub>
Low (B <sub>3</sub> )	Y <sub>1</sub> A <sub>1</sub> B <sub>3</sub>	Y <sub>2</sub> A <sub>1</sub> B <sub>3</sub>	Y <sub>1</sub> A <sub>2</sub> B <sub>3</sub>	Y <sub>2</sub> A <sub>2</sub> B <sub>3</sub>

Description:

Y<sub>1</sub>A<sub>1</sub>B<sub>1</sub>: Numeracy skills of students with high growth mindset and high LMI

Y<sub>1</sub>A<sub>1</sub>B<sub>2</sub>: Numeracy skills of students with high growth mindset and medium LMI

Y<sub>1</sub>A<sub>1</sub>B<sub>3</sub>: Numeracy skills of students with high growth mindset and low LMI

Y<sub>2</sub>A<sub>1</sub>B<sub>1</sub>: Academic achievement of students with high growth mindset and high LMI

Y<sub>2</sub>A<sub>1</sub>B<sub>2</sub>: Academic achievement of students with high growth mindset and medium LMI

Y<sub>2</sub>A<sub>1</sub>B<sub>3</sub>: Academic achievement of students with high growth mindset and low LMI

Y<sub>1</sub>A<sub>2</sub>B<sub>1</sub>: Numeracy skills of students with low growth mindset and high LMI

Y<sub>1</sub>A<sub>2</sub>B<sub>2</sub>: Numeracy skills of students with low growth mindset and medium LMI

Y<sub>1</sub>A<sub>2</sub>B<sub>3</sub>: Numeracy skills of students with low growth mindset and low LMI

Y<sub>2</sub>A<sub>2</sub>B<sub>1</sub>: Academic achievement of students with low growth mindset and high LMI

Y<sub>2</sub>A<sub>2</sub>B<sub>2</sub>: Academic achievement of students with low growth mindset and medium LMI

Y<sub>2</sub>A<sub>2</sub>B<sub>3</sub>: Academic achievement of students with low growth mindset and low LMI

## Results

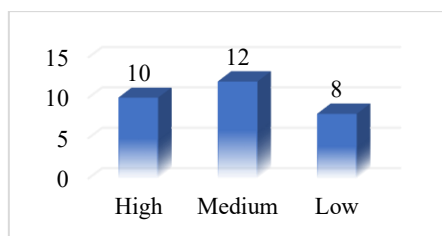
Based on descriptive statistical analysis on four variables measured on a sample of 30 students, the numerical characteristics are presented in Table 2.

**Table 2.** Numerical descriptive statistics of variables

	N	Minimum	Maximum	Mean	SD
LMI	30	20	100	55	23.55
Growth Mindset	30	51	63	58.3	3.25
Numeracy Skills	30	23	84	49.43	16.81
Academic Achievement	30	40.00	85.16	62,38	12.44

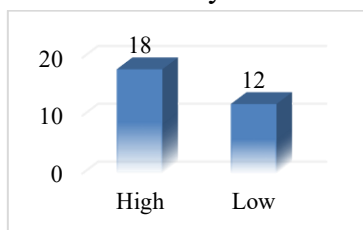
Based on Table 2, Logical-mathematical Intelligence (LMI), scores ranged from 20 to 100 ( $M = 55.00$ ,  $SD = 23.55$ ), Growth mindset scores ranged from 51 to 63 ( $M = 58.30$ ,  $SD = 3.25$ ), while academic achievement scores ranged from 40.00 to 85.16 ( $M = 62.38$ ,  $SD = 12.44$ ). Overall, the descriptive statistics indicate variability across students for all measured variables.

The characteristics of the distribution of respondents' scores for each independent variable was illustrated in Figures 1 and 2.



**Figure 1.** Histogram of frequency distribution of LMI score

Based on Figure 1, there were 10 students in the high LMI category, 12 students in the medium category, and 8 students in the low category. This shows that most students have logical-mathematical intelligence in the medium category. Meanwhile, the low category has the least number of students, which is around 8 students, which means that only a small proportion of students have less logical-mathematical ability.



**Figure 2.** Histogram of student growth mindset score frequency distribution

Based on Figure 2, it can be seen that students' growth mindset in the high category is 18 students. This shows that the majority of students have a high level of growth mindset. While in the low category there are 12 students, which means that there are some students who have a lower level of growth mindset.

Based on statistical analysis procedures, the implementation of the two-way MANOVA test requires prerequisite testing first, namely the multivariate normality test and the variance homogeneity test. The results of the prerequisite testing are presented in the following Table 3.

**Table 3.** Multivariate normality test

		Test of Normality		
	LMI	Shapiro-Wilk		
		Statistic	df	<i>p</i>
Numeracy	High	0.949	10	.652
	Medium	0.929	12	.372
	Low	0.914	8	.384
Academic Achievement	High	0.910	10	.283
	Medium	0.925	12	.331
	Low	0.968	8	.885
		GM		
Numeracy	High	0.954	18	.492
	Low	0.930	12	.377
Academic Achievement	High	0.931	18	.203
	Low	0.938	12	.477

Based on Table 3, all *p*-values from for Numeracy skills and Academic Achievement were greater than .05. Therefore, the normality assumption as one of the prerequisites of the MANOVA test has been met, so further analysis can be carried out. The next step is the homogeneity test to ensure the suitability of the data for other statistical assumptions. The results of the homogeneity test are presented in Table 4.

**Table 4.** Box's M test

Box's M	F	df1	df2	<i>p</i>	Decision
25.243	1.590	12	779.431	.089	Not significant

Based on Table 4, the value of  $p = .089 > .05$ . This indicates that the assumption of homogeneity of covariance matrices was satisfied. This ensures that the MANOVA results will be valid and in accordance with the required assumptions. The homogeneity of variance was examined using Levene's test.

**Table 5.** Levene's test of equality of error variances

	F	df1	df2	<i>p</i>
Numeracy	1.795	5	24	.152
Academic Achievement	1.549	5	24	.212

Based on Table 5, Levene's test indicated that the assumption of homogeneity of variances was satisfied for both numeracy skills ( $p = .152$ ) and academic achievement ( $p = .212$ ). Therefore, Numeracy skills and Academic Achievement have homogeneous variances across groups.

Based on the results of the statistical assumption test analysis which includes normality test, covariance homogeneity test (Box's M), and variance homogeneity test (Levene's Test), it

can be concluded that all prerequisites needed to carry out the MANOVA test have been met. Therefore, the MANOVA test analysis can be conducted and interpreted with good validity.

Furthermore, a two-way MANOVA test was used to test simultaneously the effect of two independent variables, namely logical-mathematical intelligence and student growth mindset, on two dependent variables, namely numeracy skills and student academic achievement. This test aims to determine whether there is a significant difference in the dependent variable based on these two factors. The results of the analysis are presented in Table 6 which contains hypothesis testing in this study with a significance level of .05.

**Table 6.** MANOVA analysis results

<b>Independent Variables</b>	<b>F</b>	<b>p</b>	<b>Decision</b>	<b>Interpretation</b>
Logical-Mathematical Intelligence	6.063	.001	Significant	There is a significant multivariate effect of X1 on Y1 and Y2
Growth Mindset	4.187	.028	Significant	There is a significant multivariate effect of X2 on Y1 and Y2
Interaction (X1 * X2)	0.193	.941	Not Significant	There is no significant interaction effect on the dependent variables

Based on Table 6, it can be seen that each independent variable affects the dependent variables simultaneously. Logical-mathematical intelligence (X1) showed a significant multivariate effect on numeracy skills (Y1) and academic achievement (Y2), with  $p = .001 < .05$ . Similarly, growth mindset (X2) also showed a significant multivariate effect on both dependent variables, with  $p = .028 < .05$ . However, the interaction between logical-mathematical intelligence (X1) and growth mindset (X2) did not show a significant effect on numeracy skills and academic achievement, with  $p = .937 > .05$ . This indicates that the combined effect of these two variables was not statistically significant beyond their individual contributions. Therefore, further analysis using the Tests of Between-Subjects Effects was conducted to identify more specifically which dependent variables were influenced by each independent variable.

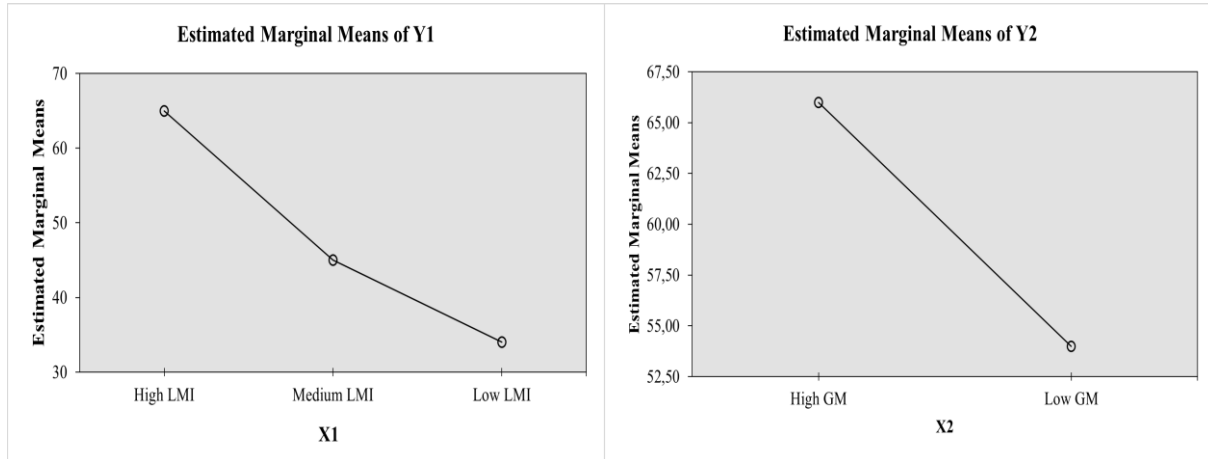
**Tabel 7.** Tests of between-subjects effects

<b>Source</b>	<b>Dependent Variable</b>	<b>F</b>	<b>p</b>
Corrected Model	Y1	9.709	< .001
	Y2	2.270	.080
X1	Y1	14.642	< .001
	Y2	0.802	.460
X2	Y1	2.902	.101
	Y2	6.229	.020
X1 * X2	Y1	0.126	.882
	Y2	0.263	.771

Based on the tests of between-subjects effects presented in Table 7, logical-mathematical intelligence (X1) had a significant effect on numeracy skills (Y1), with  $F = 14.642$  and  $p < .001$ . However, logical-mathematical intelligence did not show a significant effect on academic achievement (Y2), with  $F = 0.802$  and  $p = .460$ . Growth mindset (X2) showed a significant effect on academic achievement (Y2), with  $F = 6.229$  and  $p = .020$ , but did not have a significant effect on numeracy skills (Y1), with  $F = 2.902$  and  $p = .101$ . Furthermore, the interaction

between logical–mathematical intelligence and growth mindset ( $X1 * X2$ ) was not significant for either numeracy skills ( $F = 0.126, p = .882$ ) or academic achievement ( $F = 0.263, p = .771$ ). These results indicate that the two independent variables did not have a statistically significant interaction effect on the dependent variables.

The results of the statistical test above are further reinforced by the Estimated Marginal Means graph as follows.



**Figure 3.** Estimated Marginal Means (EMM) plot graph

The first graph in Figure 3 shows the relationship between Logical-mathematical Intelligence (X1) and Numeracy Skills (Y1). The highest mean score of Y1 was found in the High LMI group ( $M = 65.062, 95\% \text{ CI } [56.392, 73.733]$ ), followed by the Medium LMI group ( $M = 45.429, 95\% \text{ CI } [39.007, 51.850]$ ), and the lowest in the Low LMI group ( $M = 34.400, 95\% \text{ CI } [26.391, 42.409]$ ). The pattern of the means shows a consistent decrease from the high to the low LMI category. This result is consistent with the significant effect of X1 on Y1 reported in Table 7. Meanwhile, the second graph in Figure 3 shows the relationship between Growth Mindset (X2) and Academic Achievement (Y2). Students in the High GM group obtained a higher mean score ( $M = 65.841, 95\% \text{ CI } [59.836, 71.846]$ ) compared to those in the Low GM group ( $M = 54.367, 95\% \text{ CI } [47.019, 61.714]$ ). This result is consistent with the significant effect of X2 on Y2 reported in Table 7.

Based on the results of the analysis in Table 7 and Figure 3, Logical-Mathematical Intelligence (X1) had a significant effect on Numeracy Skills (Y1) and Growth Mindset (X2) had a significant effect on Academic Achievement (Y2). However, not all relationships between variables show significance, especially in the interaction between  $X1 * X2$ . Therefore, further analysis using post hoc testing was conducted to identify specific group differences for variables with more than two categories.

**Table 8.** Results of the post hoc test analysis (Y1)

Dependent Variable	(I) LMI	(J) LMI	Mean Difference(I-J)	<i>p</i>	Lower Bound	Upper Bound
Numeracy Skills	High	Medium	20.10	.001	8.42	31.84
		Low	33.05	< .001	20.08	46.02
	Medium	High	-20.13	.001	-31.84	-8.42
		Low	12.92	.041	0.43	25.40
	Low	High	-33.05	< .001	-46.02	-20.08
		Medium	-12.92	.041	-25.40	-0.43

Table 8 shows the results of a post hoc test using the Bonferroni method to compare the mean values of the dependent variable Numeracy Skills (Y1) based on Logical Mathematical Intelligence (LMI) categories, which are divided into High, Medium, and Low categories. Based on Table 8, there were significant differences between the high and medium LMI groups (mean difference = 20.13,  $p = .001$ ), between the high and low LMI groups (mean difference = 33.05,  $p < .001$ ), and between the medium and low LMI groups (mean difference = 12.92,  $p = .041$ ). This means that the higher the level of students' logical mathematical intelligence, tended to obtain higher numeracy scores.

**Tabel 9.** Results of the post hoc test analysis (Y2)

Dependent Variable	(I) LMI	(J) LMI	Mean Difference(I-J)	<i>p</i>	Lower Bound	Upper Bound
Academic Achievement	High	Medium	2.0667	> .99	-10.3389	14.4722
		Low	10.5250	.338	-3.2182	24.2682
	Medium	High	-2.0667	.181	-14.4722	10.3389
		Low	8.4583	.338	-4.7660	21.6827
	Low	High	-10.5250	.181	-24.2682	3.2182
		Medium	-8.4583	.338	-21.6827	4.7660

Based on Table 9, the results of the post hoc test analysis on the Academic Achievement (Y2) variable showed that there were no significant differences between any pairs of Logical–Mathematical Intelligence (LMI) categories, as all  $p$ -values were greater than .05. This indicates that logical–mathematical intelligence does not have a direct effect on students' academic achievement. This finding is consistent with the Tests of Between-Subjects Effects presented in Table 7, which showed that LMI (X1) had a significant effect on numeracy skills (Y1),  $F = 14.642$ ,  $p < .001$ , but did not show a significant effect on academic achievement (Y2),  $F = 0.802$ ,  $p = .460$ . In contrast, the significant effect on academic achievement was found for growth mindset (X2), which showed a significant effect on Y2,  $F = 6.229$ ,  $p = .020$ .

## Discussion

Logical-Mathematical Intelligence (X1) has a significant effect on Numeracy Skills (Y1). This indicates that students with higher LMI levels tend to demonstrate better Numeracy Skills than other groups. This finding supports cognitive perspectives on mathematical learning, which emphasize that logical reasoning, pattern recognition, and numerical processing constitute core cognitive foundations for success in mathematics-related activities (Geary, 2011). Previous research has also shown that students' ability to apply abstract and logical reasoning is closely related to their performance in problem solving and mathematical tasks (Laia et al., 2025). The results of this study indicate that logical-mathematical intelligence contributes through cognitive pathways, directly supporting students' ability to process and apply numerical information.

In addition, Growth Mindset (X2) has a significant effect on Academic Achievement (Y2). This finding suggests that students who hold the belief that their abilities may be enhanced through effort, hard work, and perseverance generally show outstanding academic achievement.

Tang et al. (2022) also support this idea by showing that growth mindset plays a role in students' academic achievement through increased engagement and self-regulated learning processes among high school students. These results are consistent with learning motivation theory, which states that students' perceptions of their abilities affect their engagement, perseverance, and readiness to invest effort in learning activities (Dweck, 2006). Recent meta-analytical research indicates that the impact of a growth mindset on academic achievement is generally positive, however not statistically significant, and highly dependent on contextual factors (Burnette et al., 2022). Overall, the findings of this study support the perspective that growth mindset works through motivation rather than through direct cognitive processes.

However, the results of the analysis also show that there is no significant relationship between Logical-Mathematical Intelligence (X1) and Growth Mindset (X2) on the two dependent variables, namely Numeracy Skills and Academic Achievement. This indicates that the cognitive contribution of logical-mathematical intelligence and the motivational contribution of growth mindset may function independently rather than synergistically in this sample. A similar trend was also shown in previous studies, which indicated that cognitive and motivational factors often contribute to learning outcomes through different mechanisms rather than through strong statistical correlations (Burnette et al., 2022; OECD, 2015).

Several factors explain the lack of significant correlation effects between cognitive and motivational factors in learning outcomes. First, the relatively small sample size ( $n = 30$ ) limits statistical power, making it difficult to detect more subtle correlation effects even if they exist in the population. Second, the accuracy of the measurement instruments. Logical-mathematical intelligence was measured using a performance-based test, while growth mindset was evaluated using a self-report questionnaire (Dweck, 2006). Differences in measurement characteristics between cognitive and psychological instruments can reduce the likelihood of observing interaction effects in quantitative analysis. Third, contextual factors such as curriculum structure, teaching practices, and classroom learning culture can influence the relationship between cognitive and motivational factors in practice (OECD, 2015)

From a theoretical perspective, these findings are consistent with models that distinguish between cognitive and motivational pathways in learning. Logical–mathematical intelligence appears to support students' capacity to process information and solve problems, whereas growth mindset appears to support students' willingness to engage, persist, and regulate effort during learning. Given that these two factors contribute through different mechanisms, their effects may appear independently rather than interactively.

Overall, this study shows that logical-mathematical intelligence plays an important role in the development of students' numeracy skills, while a growth mindset contributes more strongly to students' overall academic achievement. The results of this study highlight the importance of attending to both cognitive and affective elements in educational practice, rather than prioritizing only one aspect. However, the independent nature of these effects also suggests that developing a growth mindset alone may not be sufficient to improve students' numeracy skills without simultaneous support for cognitive development.

## Conclusion

This study indicates that logical-mathematical intelligence plays an important role in enhancing students' numeracy skills. Students with high logical-mathematical intelligence have numeracy skills. Meanwhile, growth mindset contributes to students' academic achievement. This means that students with high growth mindset show greater motivation and perseverance, which has a positive impact on their academic achievement. While these two variables have a significant impact on various aspects, there is no interaction between logical-mathematical intelligence and growth mindset in affecting numeracy skills or academic achievement. This suggests that they operate independently, without any additional combined effect on students' numeracy skills and academic performance. These findings indicate that developing logical-mathematical intelligence can be an effective method for improving students' numeracy skills, while developing a growth mindset is important for improving students' academic achievement. Therefore, educational methodologies must incorporate an integrated cognitive and affective dimension of learning.

There are some limitations with this study that need to be pointed out. First, the sample size was relatively small, which could limit the adequacy of statistical analysis. Second, data were collected from only one school, limiting the generalizability of the findings. Third, this study used a cross-sectional design, which did not allow for causal conclusions to be drawn. Further research is recommended to involve a larger and more diverse sample, apply a longitudinal research design to observe changes over time, and conduct experimental studies that combine mindset-based interventions with numeracy teaching to understand the combined effects of these factors.

## Acknowledgment

The authors would like to express their sincere gratitude to the Master of Mathematics Education Program at Sebelas Maret University for the academic support provided during this research. Special thanks are extended to Andrik Noor Hanafi, S.Pd and the students for their cooperation and participation in this research. The authors also acknowledge Dr. Getut Pramesti for her valuable assistance in the data analysis process.

## Declarations

- Conflicts of Interest : The authors confirm that there are no conflicts of interest related to the publication of this article.
- Generative AI Statement : No Generative AI Used, tools were used only to assist with language editing and clarity. All conceptualization, analysis, and scholarly content were independently developed and verified by the authors.
- Funding Statement : This work received no specific grant from any public, commercial, or not-for-profit funding agency.

Author Contributions : **Nurul Munzayanah:** Contributed to the conceptualization, original draft, data collection, data analysis, and editing of the manuscript. **Budi Usodo:** Provided supervision, methodological guidance, and critical review of the paper. **Laila Fitriana:** Contributed to supervision, review, and validation of the findings. **Getut Pramesti:** Assisted in the data analysis and contributed to the validation of the results.

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