



## How Do Pre-Service Language Teachers Perform in Mathematical Literacy? A Study at the Tertiary Level

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### Abstract

Mathematical literacy is increasingly recognized as a critical competency for all university students, including those in non-STEM disciplines. However, language education students are often overlooked in discussions surrounding mathematical reasoning. This study examines the mathematical literacy performance of tertiary-level students enrolled in Arabic, Indonesian, and English language education programs. Using a quantitative descriptive design, data were collected from 91 students through assessments covering linear equations, inequalities, graphing functions, and quadratic equations. The study employed one-way ANOVA and Kruskal–Wallis tests to analyze differences in performance. While overall scores did not differ significantly across majors, notable differences were observed in component-level indicators, particularly in Employ and Interpret processes. Indonesian Language Education students demonstrated stronger skills in problem formulation and procedural application, while Arabic Language Education students excelled in interpreting mathematical results. In contrast, English Language Education students showed high procedural ability but struggled with interpretation. These findings highlight uneven cognitive development in mathematical reasoning across programs and underscore the need for integrating numeracy into language education curricula. Recommendations include differentiated instructional strategies, cross-disciplinary teacher training, and policy support to promote holistic and interdisciplinary competencies among future educators.

**Keywords:** Mathematical Literacy; Language Education; Cognitive Development; Interdisciplinary Learning; Non-STEM Students

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## INTRODUCTION

Mathematical literacy is increasingly recognized as an essential 21st-century competency, extending beyond basic numeracy to encompass the capacity to reason mathematically and apply mathematical concepts, procedures, facts, and tools to solve problems in diverse real-world contexts (Development, 2022; Golla & Reyes, 2022; Stacey & Turner, 2015). Having strong mathematical literacy skills is more important than ever, and not just for scientists or engineers. Mathematical literacy, is now recognized as an essential skill for everyone (Marhami et al., 2024). Whether making financial decisions, interpreting data, or engaging in critical discussions, mathematical literacy helps individuals navigate the complexities of modern life.

Over the last two decades, educational systems around the world have placed a growing emphasis on developing students' mathematical literacy. International assessments like PISA (Programme for International Student Assessment) have repeatedly shown that students who can think mathematically tend to perform better not only in academic settings but also in everyday life challenges (OECD, 2019; Rohantizani et al., 2022). As a result, many curricula especially in STEM (Science, Technology, Engineering, and Mathematics) fields have incorporated mathematical literacy goals to prepare students for the demands of a rapidly evolving, data-rich society.

The importance of mathematical literacy extends universally, underpinning critical thinking and problem-solving skills applicable across disciplines (Burrill, 2022; Runtu et al., 2023). While vital for STEM, non-STEM students also require functional mathematical literacy to interpret data, manage resources, and engage with quantitative aspects within their fields and daily lives (Elrod & Park, 2020; Mahyudi et al., 2024). A lack of these skills can impede academic success even in theoretically-focused subjects (Mahmud & Pratiwi, 2019).

However, despite this growing recognition, a concerning gap remains at the university level, particularly among students in non-STEM fields. Research shows that while students in science, technology, engineering, and mathematics programs often achieve high levels of mathematical literacy, those studying the humanities, arts, and language education frequently struggle with basic mathematical reasoning and problem-solving (Geiger et al., 2015; Rohantizani et al., 2022). (Golla & Reyes, 2022; Hamidi et al., 2024) found that non-STEM students faced challenges with higher-level questions.

Previous research at the university level also has often compared STEM and non-STEM students, generally finding lower quantitative reasoning scores among non-STEM groups, although overall performance for both is often low (Elrod & Park, 2020). Studies involving pre-service teachers indicate correlations between reading culture or general literacy and mathematical self-efficacy or critical thinking (Hamidi et al., 2024; Slameto, 2003), but also highlight concerns about teachers' efficacy, particularly non-STEM teachers integrating math (Burrell & Burrell, 2018; Burrill, 2022). Overall achievement in mathematical and related literacies among university students has been found to be worryingly low in some studies (Yurt & Tunkler, 2019).

What is even more concerning is that language education students, future teachers who will shape the next generation's cognitive skills, are often overlooked in discussions about mathematical literacy. Their academic paths emphasize linguistic and communication skills, sometimes at the expense of logical reasoning and analytical thinking. Yet, skills like critical reasoning, problem-solving, and evidence-based thinking, which are nurtured through mathematical literacy, are just as important for language teachers as they are for scientists (Steen, 2001).

A significant connection exists between language skills and mathematical understanding. Research consistently shows that reading comprehension, vocabulary, and syntactic knowledge strongly correlate with mathematical performance, particularly in understanding and solving word problems (Grimm, 2008; Peng Peng et al., 2020; Sobkow et al., 2020). Mathematical literacy itself fosters critical thinking skills like analysis, reasoning, and evaluation, which are highly valuable for language education students (Kolar & Hodnik, 2021; Slameto, 2003). This interplay suggests that language proficiency can be both a potential hurdle and a unique asset in developing mathematical literacy.

Integrating mathematical literacy into language education is therefore not merely an academic exercise; it is a necessity. Future language educators equipped with mathematical thinking skills can teach students to reason systematically, argue logically, and make informed decisions (skills that transcend disciplines). As (Akmal, 2025; Geiger et al., 2015) argue, promoting numeracy across the curriculum supports holistic student development and prepares them for real-world challenges.

Despite these insights, little research has specifically explored the mathematical literacy levels of language education students. Most studies lump non-STEM students into a single group without considering the unique educational needs of those preparing to become language teachers. Moreover, prior research often emphasizes theoretical knowledge rather than practical, real-world mathematical problem-solving.

However, a specific gap exists in the literature regarding the mathematical literacy performance of language education students at the tertiary level. This study seeks to fill that gap by investigating how students from Arabic Language Education, Indonesian Language Education, and English Language Education programs perform in mathematical literacy tasks, specifically examining performance differentiation in the Formulate, Employ, and Interpret processes. By focusing on basic mathematical problems such as linear equations, inequalities, graphing functions, and quadratic equations, this research sheds light on the specific strengths and challenges these students face. In doing so, it offers fresh insights into how mathematical literacy can be meaningfully integrated into language education, ultimately contributing to more well-rounded and capable future educators.

## METHOD

### Research Design

This study employed a quantitative descriptive research design. The aim was to systematically describe and analyze the mathematical literacy skills of language education students at the tertiary level. A quantitative approach was selected to allow for objective measurement and statistical analysis of students' performance on a set of mathematical literacy tasks. The descriptive approach was chosen to provide an in-depth understanding of students' proficiency levels, common errors, and patterns in responding to basic mathematics questions.

### Participants and Sampling

The participants of this study were undergraduate students from three language education programs at a university in Aceh: Arabic Language Education, Indonesian Language Education, and English Language Education. A total of 94 students voluntarily participated in the study. The participants represented diverse academic backgrounds and were enrolled in their respective programs during the academic year 2024/2025. The selection of these participants aimed to capture the mathematical problem-solving competencies of future educators in language disciplines, who typically have limited exposure to mathematics in their curricula.

**Table 1.** Participant Characteristics

No.	Study Program	Number of Participants (n)	Gender Distribution (M/F)
1	Arabic Language Education	31	9/22
2	Indonesian Language Education	21	0/21
3	English Language Education	39	8/31
<b>Total</b>		<b>91</b>	<b>17/74</b>

### Instruments and Procedures

The primary instrument used in this study was a set of basic mathematics examination questions, which covered fundamental mathematical concepts and problem-solving tasks. The exam consisted of linear equations, linear inequalities, graphing linear functions, and solving quadratic equations. These questions were designed to assess students' abilities to interpret mathematical problems, apply appropriate solution strategies, and present accurate answers. The instrument was developed based on standard mathematics curricula for non-STEM

students at the university level and validated by subject matter experts prior to its administration.

**Table 2.** Research Instruments

No.	Type of Question	Description	Indicator Assessed
1	Linear Equation	Solve $2x - 4 = x - 4 + a$	Ability to solve basic linear equations
2	Linear Equation	Solve $5x - 3 = 2(x - 1) - a$	Understanding of distributive property and simplification
3	Linear Inequality	Solve $6x < a$	Ability to solve linear inequalities
4	Linear Inequality	Solve $2(x + 5) < a$	Application of algebraic manipulation in inequalities
5	Graphing Linear Function	Draw the graph of $F(x) = a$	Understanding of constant functions and graphing
6	Graphing Linear Function	Draw the graph of $F(x) = x + a$	Ability to graph linear functions
7	Quadratic Equation	Solve $x^2 + x - a = 0$	Problem-solving involving quadratic equations

The instrument was developed based on widely accepted mathematical literacy frameworks and was reviewed by two mathematics education experts to ensure validity and content relevance.

Data were collected through documentation of students' completed exam papers. The exam was administered in a controlled classroom setting, and students were required to complete the tasks individually without external assistance. After the examination, students' answer sheets were collected, organized, and coded for analysis.

Student responses were scored based on a predefined rubric focusing on indicators of mathematical literacy: accuracy, reasoning, and application of mathematical concepts. To describe students' mathematical literacy in solving problems, indicators are needed in analyzing the formulate, employ and interpret processes. The indicators used to analyze the three processes are presented in Table 3.

**Table 3.** Mathematical Literacy Indicators

Mathematical Literacy Process	Indicators	Number of Questions
<b>Formulate</b>	Identify important aspects of the given problem.	1, 2, 3, 4
	Represent the problem using appropriate variables, symbols, diagrams, and modelling. Design and implement strategies for finding mathematical solutions.	
<b>Employ</b>	Use facts, concepts, procedures, and mathematical reasoning when looking for solutions.	5, 6
	Interpret a mathematical solution contextually.	
<b>Interpret</b>	Re-check the mathematical solution obtained.	7
	Explain why a mathematical solution makes sense or not.	

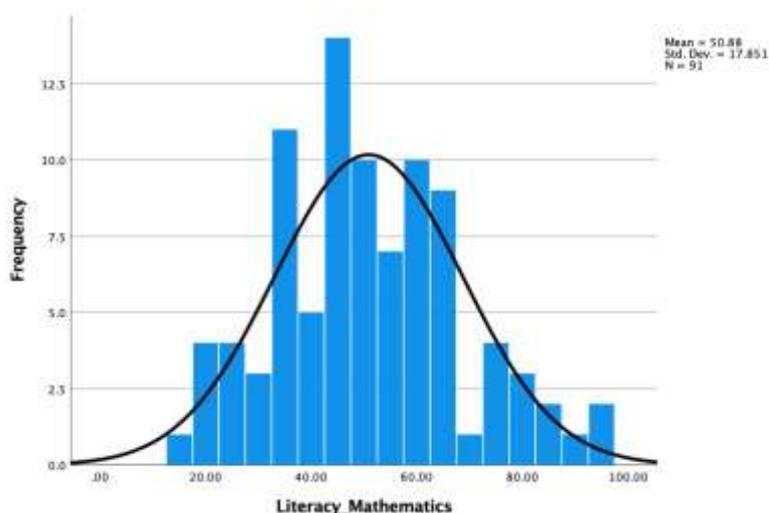
## Data Analysis Techniques

The analysis focused on: descriptive statistics, a comparative analysis was conducted to explore potential differences in performance among the three study programs. A simple statistical test, such as Chi-square test or ANOVA, was applied to examine whether significant differences existed between the groups in terms of their mathematical problem-solving abilities. The findings from this analysis are presented in the following sections, highlighting both the quantitative results and qualitative insights derived from students' responses.

## RESULTS AND DISCUSSION

### Descriptive Statistics

Figure 1 presents a histogram of students' total scores in the mathematical literacy assessment. The distribution appears roughly symmetrical and bell-shaped, indicating an approximately normal distribution. The mean score was  $M = 50.88$ , with a standard deviation of  $SD = 17.85$ , suggesting moderate variability in performance. The total sample size was  $N = 91$ . Most scores clustered between 35 and 65, indicating that a majority of students performed within a mid-range level of mathematical literacy. There were few extreme scores on either end of the distribution, and no strong skewness was observed, supporting the assumption of normality. This impression was corroborated by statistical testing in the next section.

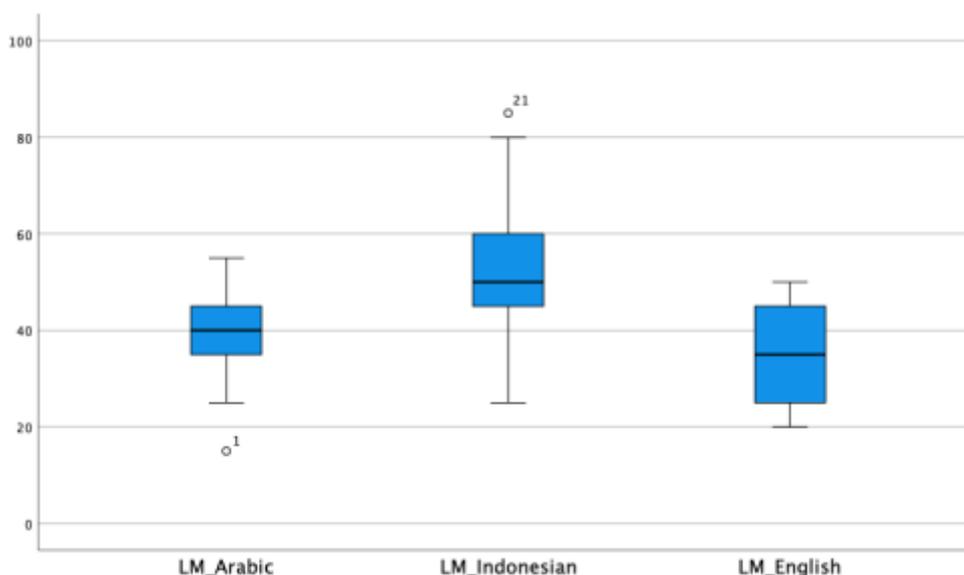


**Figure 1.** Histogram of Overall Mathematical Literacy Scores

### Score Comparison by Majors

An overall comparison of grades by major will be displayed in Figure 2. Figure 2 displays boxplots comparing the score distributions among the three language education majors. A clear distinction is observed in the central tendency and variability of the scores across the three groups. Students in the Indonesian Language Education program exhibited the highest median score, suggesting a relatively stronger overall performance in mathematical literacy. Their scores were also spread over a wider range, with one notable high outlier, indicating that some students in this group achieved exceptionally high scores.

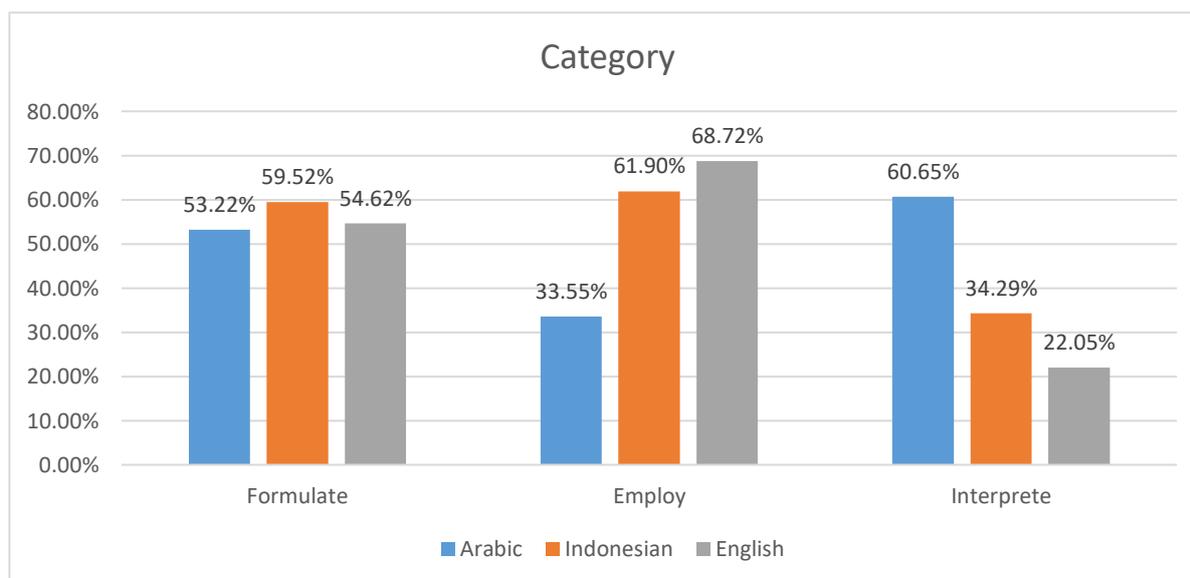
In contrast, English Language Education students displayed a broader interquartile range (IQR) and the lowest median score, pointing to greater inconsistency in performance and a generally lower level of achievement. The Arabic Language Education group had the most compact score distribution with a median slightly lower than the Indonesian group, indicating more homogeneous but moderate performance among students in this program. An outlier on the lower end was also present in this group, indicating at least one student struggled considerably with the assessment.



**Figure 2.** Boxplots of Mathematical Literacy Scores by Major

### Indicator-Based Performance

The bar graphs in Figure 3 summarize students' performance across the three mathematical literacy processes: Formulate, Employ, and Interpret. The analysis highlights nuanced differences across the majors. In the Formulate process, which involves identifying relevant information and representing problems mathematically, students from the Indonesian Language Education program achieved the highest scores ( $M = 14.88$ , 59.52%). They were followed by English Language Education students ( $M = 13.65$ , 54.62%) and Arabic Language Education students ( $M = 13.31$ , 53.22%). Although the difference was not statistically significant, the Indonesian group demonstrated slightly better skills in translating problems into mathematical terms.



**Figure 3.** Bar Graphs of Scores per Mathematical Literacy Indicator by Major

In the Employ process, which tests the use of mathematical concepts and procedures, English Language Education students outperformed their peers ( $M = 17.18$ , 68.72%). This result is notable given their relatively lower overall scores, suggesting that while they may struggle with problem formulation and interpretation, they possess strengths in applying

mathematical procedures. Indonesian Language Education students followed ( $M = 15.48$ , 61.90%), while Arabic Language Education students lagged behind ( $M = 8.39$ , 33.55%).

Finally, in the Interpret process—concerned with evaluating solutions and reflecting on their contextual validity—Arabic Language Education students performed best ( $M = 15.16$ , 60.65%). Indonesian students achieved a moderate score ( $M = 8.57$ , 34.29%), while English students showed the weakest performance ( $M = 5.51$ , 22.05%). These differences reveal varied profiles of mathematical strengths and weaknesses among the groups, emphasizing the need for targeted instructional strategies.

### Statistical Results

To determine whether the differences in mathematical literacy scores among the three language education programs were statistically significant, a one-way analysis of variance (ANOVA) was conducted. Before performing the ANOVA, tests of normality and homogeneity of variances were used to verify the assumptions.

**Table 4.** Overall Normality Test Value

No	Variabel	Shapiro-Wilk		
		Statistic	df	Sig
1	Arabic Language Education	0.958	31	0.255
2	Indonesian Language Education	0.961	21	0.541
3	English Language Education	0.958	39	0.148

The Shapiro–Wilk test of normality indicated that score distributions in all three groups did not significantly deviate from normality, with p-values of .255 for Arabic Language Education; .541 for Indonesian Language Education, and .148 for English Language Education. As all values exceeded the alpha level of .05, the assumption of normality was considered satisfied.

**Table 5.** Levene's test of homogeneity of variances

Levene Statistic	df 1	df 2	Sig.
2.752	2	91	0.144

Levene's test for homogeneity of variances indicated that the assumption of equal variances was met ( $F(2, 91) = 2.75$ ,  $p = .144$ ).

**Table 6.** Anova Test of Mathematic Literacy

Mean Square	df	F	Sig
117.94	2	0.365	0.695

The one-way ANOVA indicated no statistically significant differences in overall mathematical literacy scores among the three majors,  $F(2, 91) = 0.37$ ,  $p = .695$ . Although descriptive statistics showed slight differences in mean scores, these differences were not statistically significant.

**Table 7.** Normality Test Scores of Each Major

Variable	Shapiro-Wilk		
	Statistic	df	Sig
ALE_Formulate	0.967	31	0.449
ALE_Employ	0.777	31	0.000
ALE_Interpret	0.896	31	0.006
ILE_Formulate	0.841	21	0.003
ILE_Employ	0.919	21	0.084

Variable	Shapiro-Wilk		
	Statistic	df	Sig
ILE_Interpret	0.877	21	0.013
ELE_Formulate	0.942	39	0.044
ELE_Employ	0.860	39	0.000
ELE_Interpret	0.727	39	0.000

Note: ALE : Arabic Learning Education; ILE : Indonesian Learning Education; ELE : English Learning Education

The results of examining each mathematical literacy indicator individually, several variables violated the normality assumption based on the Shapiro–Wilk test. Therefore, the non-parametric Kruskal–Wallis H test was conducted for each indicator: Formulate, Employ, and Interpret.

### **Formulate**

The results of the Kruskal-Wallis test indicated that there were no significant differences in the *Formulate* indicator across the three groups,  $H(2) = 1.07$ ,  $p = .586$ . Since  $p > .05$ , we conclude that there were no significant differences in performance on this indicator.

**Table 8.** Kruskal-Wallis Score for Formulate Indicators

Kruskal-Wallis H	df	Asymp. Sig
1.069	2	0.586

### **Employ**

The results of the Kruskal-Wallis test indicated a statistically significant difference in the *Employ* indicator,  $H(2) = 23.06$ ,  $p < .001$ . These results suggest that there were significant differences in performance across the three groups on this indicator.

**Table 9.** Kruskal-Wallis Score for Employ Indicators

Kruskal-Wallis H	df	Asymp. Sig
23.056	2	0.000

### **Interpret**

The results of the Kruskal-Wallis test showed a statistically significant difference in the *Interpret* indicator,  $H(2) = 23.06$ ,  $p < .001$ . These results indicate significant differences in performance across the three groups on this indicator.

**Table 10.** Kruskal-Wallis Score for Interpret Indicators

Kruskal-Wallis H	df	Asymp. Sig
23.056	2	0.000

## **Discussion**

### **Interpretation of Major Findings**

The analysis revealed that, although there were no statistically significant differences in overall mathematical literacy scores among the three majors, each group demonstrated distinct strengths in specific literacy components. Students from the Indonesian Language Education program performed relatively well in the Formulate and Employ indicators, suggesting that these students possess stronger abilities in identifying, representing, and solving mathematical problems. This may stem from instructional emphasis on systematic thinking or greater exposure to structured learning activities in their curriculum.

In contrast, English Language Education students, despite showing the lowest overall scores, achieved the highest average in the Employ component. This discrepancy implies that their procedural mathematical knowledge is relatively strong, even though they may struggle to contextualize or interpret mathematical outputs. On the other hand, Arabic Language

Education students excelled in the Interpret component, indicating a more developed capacity for validating and reflecting on mathematical outcomes, a skill possibly nurtured through their curriculum's focus on textual analysis and logical interpretation.

### ***Comparisons with Previous Research***

These results align with findings from previous research showing that non-STEM students, particularly in the humanities, often have uneven mathematical competencies across different cognitive domains (Burrell & Burrell, 2018; Elrod & Park, 2020; Geiger et al., 2015). The performance profile of English majors—strong in procedures but weak in interpretation—resonates with concerns raised by (Aida et al., 2017), who observed that non-STEM students often lack critical thinking skills when confronting quantitative tasks. The high interpretative performance of Arabic majors also supports assertions by (Grimm, 2008) and (Kolar & Hodnik, 2021) regarding the potential positive influence of linguistic-analytical training on mathematical reasoning.

### ***Pedagogical Implications***

The differentiated performance across literacy components emphasizes the need for targeted curricular interventions. For Indonesian majors, curriculum reinforcement should aim to maintain and further develop their problem-formulation capabilities. For English majors, instruction should integrate reflective and interpretive problem-solving tasks, such as case-based scenarios or multi-step problems that require critical evaluation. Arabic majors, while strong in interpretation, need more structured exposure to procedural practice to strengthen their computational fluency.

This study highlights that mathematical literacy must be integrated into language education not as an add-on, but as a core competency, reinforcing the interdisciplinary nature of teaching. Teacher education programs should incorporate numeracy-infused modules, where language students engage with mathematical content through context-rich language tasks. Doing so can develop their holistic reasoning skills and prepare them to teach students who will face increasingly quantitative and data-rich environments.

The findings support calls from (Geiger et al., 2015; Stacey & Turner, 2015) for numeracy across the curriculum, advocating that mathematical literacy is essential for all disciplines, not just STEM. Moreover, (Burrill, 2022) emphasizes the importance of statistical and quantitative reasoning in developing informed citizens—a goal aligned with national and global education standards such as those proposed in the OECD Learning Compass 2030 (Taguma et al., 2023) Integrating mathematical thinking within language instruction, as argued by (Steen, 2001), equips future educators to foster both critical and quantitative literacies in their own classrooms.

Furthermore, the interplay between language and mathematics, discussed by (P Peng et al., 2020; Sobkow et al., 2020), reinforces the argument that linguistic proficiency can significantly shape mathematical thinking. Language educators trained in numeracy can better guide their students in understanding mathematical texts, interpreting data-driven content, and solving complex word problems—thus promoting interdisciplinary synergy. By embracing these pedagogical shifts, universities can cultivate educators who are analytically versatile and pedagogically innovative.

### ***Study Limitations and Future Directions***

One limitation of this study is the focus on a single institution and a relatively small, convenience-based sample, which may not capture the broader variability in language education programs nationwide. Additionally, while the test items reflected basic mathematical skills relevant to non-STEM students, they may not fully represent complex, real-life applications of mathematical literacy.

Future studies should consider longitudinal designs to examine the development of mathematical literacy over time and across different instructional models.

Furthermore, qualitative investigations—such as interviews or think-aloud protocols—can yield deeper insights into students' cognitive processes and the specific challenges they encounter. Broader, multicenter studies could also enhance the generalizability of the findings and help shape national curriculum reforms aimed at embedding mathematical thinking in all teacher education programs.

## CONCLUSION

This study investigated the mathematical literacy performance of tertiary-level students enrolled in Arabic, Indonesian, and English language education programs. Although the overall average score was modest across the three groups, statistical analysis revealed no significant differences in total mathematical literacy scores among the majors. These findings indicate a shared challenge among non-STEM students in mastering basic mathematical competencies.

However, deeper analysis by literacy indicators uncovered meaningful variations. Students in the Indonesian Language Education program demonstrated relatively stronger abilities in the Formulate process, while English Language Education students excelled in the Employ indicator, suggesting higher procedural proficiency. In contrast, Arabic Language Education students showed superior performance in the Interpret process, highlighting strengths in validating and reasoning through mathematical outcomes.

The Kruskal–Wallis test confirmed that significant differences exist for the Employ and Interpret indicators, though not for the Formulate process. These findings emphasize that while general mathematical literacy levels may appear comparable across majors, students possess distinct cognitive profiles in specific domains of mathematical thinking.

These findings underline the importance of integrating mathematical literacy into language education curricula, particularly through interdisciplinary modules and contextualized mathematical tasks in language instruction. Strengthening application skills among Arabic majors and enhancing reflective reasoning in English majors could support a more balanced development of interdisciplinary competencies. As future educators, language students must be equipped not only with linguistic expertise but also with logical, quantitative, and evaluative skills to meet the broader demands of education in the 21st century.

## RECOMMENDATION

In light of the findings, this study recommends the integration of mathematical literacy components into language education curricula. These components should be contextualized to align with linguistic content, promoting interdisciplinary competencies and enabling students to develop critical thinking and quantitative reasoning skills essential for real-world applications.

Instructional strategies should be differentiated to address the observed disparities among the programs. English Language Education students, who excelled in procedural applications but struggled with interpretive reasoning, may benefit from problem-solving exercises that emphasize reflection and contextual analysis. Conversely, Arabic Language Education students may require targeted support in building procedural fluency through scaffolded practice and visual problem representations.

To support implementation, teacher education programs should offer professional development opportunities focused on cross-disciplinary pedagogy. This includes training pre-service language teachers in basic mathematical reasoning and demonstrating how to integrate such skills into their future teaching practices. Collaborative initiatives between mathematics and language education departments could foster shared expertise and innovation.

Further research is also essential. Longitudinal studies and intervention-based designs could explore the long-term impacts of interdisciplinary instruction on both academic performance and pedagogical efficacy. Additionally, qualitative inquiries into students' perceptions and institutional constraints may provide valuable insights for policy and curriculum development.

Finally, educational policymakers are encouraged to recognize numeracy as a core competency across all disciplines. Institutional support for interdisciplinary curriculum design, funding for pilot programs, and national guidelines on cross-curricular literacy could significantly advance this agenda. By empowering language educators with mathematical literacy, institutions can nurture well-rounded graduates equipped to engage meaningfully in a complex, quantitative world.

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#### AUTHOR CONTRIBUTIONS STATEMENT

This journal uses the Contributor Roles Taxonomy (CRediT) to recognize individual author contributions, reduce authorship disputes, and facilitate collaboration.

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C : Conceptualization

M : Methodology

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E : Writing - Review & Editing

Vi : Visualization

Su : Supervision

P : Project administration

Fu : Funding acquisition

#### CONFLICT OF INTEREST STATEMENT

The authors state that they have no conflict of interest related to the research, authorship, or publication of this article.

#### INFORMED CONSENT

We have obtained informed consent from all individuals included in this study.

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