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Research Article

The Implementation of the Inquiry-Based Learning Model in Improving Elementary School Students' Numeracy and Literacy Skills

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Abstract: This study analyzes the effect of the inquiry-based learning model on elementary school students' numeracy literacy skills. Using a pre-experimental one-group pretest–posttest design with 30 fifth-grade students, data were collected via essay-based tests. The results showed a significant increase in numeracy literacy, with the average score rising from 59.77 on the pretest to 82.53 on the posttest. Statistical validation through a paired-samples t-test yielded a t-value of -145.275 ($p < 0.05$), confirming that the improvement was not due to random chance. Furthermore, an N-Gain analysis of 0.788 indicates a high level of improvement. Deeper analysis using the Pearson product–moment correlation revealed a very strong positive relationship of 0.991 ($p = 0.000$) between pretest and posttest scores. This demonstrates that student progress was highly consistent across the group, meaning the intervention effectively benefited both high- and low-achieving students similarly. These findings suggest that inquiry-based learning effectively enhances numeracy literacy by encouraging active involvement and contextual problem-solving.

Keywords: elementary education, inquiry-based learning model, numeracy literacy

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INTRODUCTION

Education is the fundamental foundation for developing high-quality human resources by strengthening cognitive skills, character, and student competencies holistically (Khalil et al., 2024). In the modern educational paradigm, students are required to master 21st-century skills, including critical thinking, creativity, and problem-solving abilities (Herlinawati et al., 2024). Therefore, literacy is a crucial prerequisite for students to understand, analyse, and utilise information effectively (Utami et al., 2025). Specifically, literacy today is not limited to the ability to read and write, but also encompasses numeracy literacy, which enables students to apply mathematical concepts in various aspects of real-life situations (Nityasanti et al., 2025).

Numeracy literacy skills are fundamental because students need to understand mathematical concepts to solve contextual problems (Astuti & Sumarno, 2025). In addition, numeracy literacy helps students process information logically and make data-driven decisions (Fitriani et al., 2025). Given the importance of this role, the low numeracy achievement underscores the urgency of transforming the learning models that support the development of these competencies (Setiawan et al., 2024). Thus, numeracy literacy not only impacts academic achievement but also serves as an essential life skill for students (Anggraini et al., 2025).

However, the reality on the ground shows a significant gap between the demand for these competencies and students' actual achievements in Indonesia (Jannati et al., 2025). The 2022 PISA data reveal that only 18% of Indonesian students meet the minimum competency level in numeracy, a figure far below the OECD average of 69% (OECD, 2022). This low numeracy ability directly impacts students' limitations in critical thinking and in solving everyday problems systematically (Anggraini et al., 2025). Despite these concerning trends, little is known about the underlying factors contributing to the low numeracy literacy among Indonesian students. Therefore, research examining these factors is urgently needed (Islami et al., 2025). Empirical findings in this field will provide an important foundation for exploring more effective learning models, especially at the elementary school level (Fitriani et al., 2025).

A number of studies have shown that learning models that emphasise active student involvement in investigating and observing phenomena can significantly improve numeracy skills (Mauliana et al., 2025). Previous research has also highlighted the importance of developing critical thinking skills through instructional activities that encourage analysis and reflection (Waruwu & Helsa, 2025). This strengthens the argument that numeracy literacy can be optimised through contextual and participatory learning experiences (Adsar, 2025). Therefore, exploring innovative learning models is highly relevant to improving the quality of primary education (Ghufron & Andri, 2025).

This study aims to fill this gap by exploring how the inquiry-based learning model can help elementary school students in Indonesia improve their numeracy literacy skills. The study emphasises the local context and demonstrates the potential of the inquiry model to address the challenges in Indonesia. By focusing on the specific needs of elementary students, the research seeks to understand how inquiry-based learning can enhance numeracy literacy. The research will also assess whether there is a significant difference in students' numeracy literacy skills before and after the application of the inquiry-based learning model.

The results of this study are expected to provide a comprehensive understanding of effective methods for improving students' numeracy competence. Additionally, the study will contribute to the development of more relevant and effective learning models in Indonesian

education, particularly by enhancing numeracy literacy in elementary schools. By offering insights into how inquiry-based learning can foster better numeracy skills, this research will support educators in adopting innovative teaching strategies. Ultimately, it aims to strengthen numeracy literacy, a vital life skill for students in both academic and real-world settings.

THEORETICAL FRAMEWORK

Numeracy literacy is the ability of students to comprehend, use, and interpret mathematical concepts in various real-life contexts, logically and systematically (Y. L. Dewi & Hidayat, 2025). This concept not only includes mastery of calculation procedures but also involves application-oriented reasoning and problem-solving skills (Amidi, 2024). This perspective aligns with cognitive constructivist theory, which emphasises that conceptual understanding develops through active processes of meaning-making (Fanggidae et al., 2024). Therefore, numeracy literacy is positioned as a conceptual competence that develops through high-level thinking activities and critical reflection (Pangestika et al., 2025).

The development of numeracy literacy is closely related to social constructivist theory, which emphasises the importance of social interaction and scaffolding support in the learning process (Ahmadakbar et al., 2025). This theory explains that students can reach higher levels of understanding when engaged in discussions and collaborations during instructional activities (Dewi & Subagya, 2025). This principle serves as the basis for implementing the inquiry-based learning model, which positions students as active subjects in the investigative process (Qablan et al., 2024). The inquiry-based learning model allows students to ask questions, gather data, and draw conclusions independently and reflectively (Jannah et al., 2025).

Information processing theory provides a framework for explaining how inquiry-based learning enhances numeracy literacy. The relationship between the inquiry-based learning model and numeracy literacy can be explained through information processing theory. This theory states that effective learning occurs when students actively process information based on concrete experiences (Haqi et al., 2023). Investigative activities in learning encourage students to organise numerical information systematically, leading to the formation of a stable understanding structure (Qablan et al., 2024). The process of exploration and reflection also reduces dependence on procedural memorisation while enhancing flexibility in solving contextual problems. Thus, inquiry-based learning models theoretically support the development of deeper and more functional numeracy skills (Sam, 2024).

This study assumes that learning models that stimulate active engagement, social interaction, and cognitive reflection will improve elementary school students' numeracy literacy. This assumption is based on the integration of social constructivism theory and information processing theory, which emphasise the importance of meaningful learning experiences (Baharuddin, 2025). The measurement indicators in this study are directly derived from the dimensions of concept understanding, logical reasoning, and numerical problem-solving skills (Suryaningsih et al., 2025). The integration of theoretical foundations, research variables, and operational indicators ensures that this research has a strong conceptual basis and scientific validity that can be accounted for (Asri & Maysarah, 2024).

METHODS

Research Design

This study uses a quantitative approach with a pre-experimental, one-group pretest–posttest design. This design is used to measure changes in students' numeracy literacy skills before and after the implementation of the inquiry-based learning model. The measurement is conducted twice on the same group, once before the treatment (pretest) and once after the treatment (posttest), allowing the impact of the intervention to be directly and measurably observed (Creswell & Creswell, 2023).

The one-group pretest–posttest design allows the researcher to see the extent to which the learning intervention affects students' numeracy literacy skills. With measurements taken before (pretest) and after (posttest) the treatment, changes can be observed directly and concretely (Zhou & Chen, 2022). This helps ensure the inquiry-based learning model's impact can be analysed more accurately. The details of the research design are shown in the following Table 1.

Table 1. One-Group Pretest–Posttest Design

Pre-test	Independent Variable	Post-test
O_1	X	O_2

Explanation:
O_1 : Pretest
X : Application of the Inquiry-Based Learning Model
O_2 : Posttest

Sample

The subjects of this study were all fifth-grade students at Sekolah A, totalling 30 students. The sampling technique used was saturated sampling, which involves including the entire population as the research sample. Saturated sampling was chosen because the population is relatively small and all students are in the same learning environment. Involving all students aimed to provide a comprehensive picture of the impact of the application of the inquiry-based learning model on students' numeracy literacy skills (Sugiyono, 2023).

This approach ensures that all students are included in the study, thereby making the findings representative of the entire population within the sample. By using a saturated sampling method, the research avoids sampling biases and provides more reliable results. Furthermore, this technique allows for an in-depth analysis of the intervention's effects across the entire group. Including all students in the research helps draw more generalizable conclusions about the impact of the inquiry-based learning model.

Data Collection

The data collection technique in this study used a numeracy literacy ability test, administered as a pretest and posttest. The test instrument consisted of essay-type questions designed to measure students' abilities before and after the application of the inquiry-based learning model. The test instrument was developed based on three aspects of numeracy literacy: calculation ability, numeracy relations, and arithmetic operations (Purpura, 2010). These three aspects were chosen because they represent the understanding of concepts, logical reasoning, and numerical problem-solving skills that are developed through the stages of the inquiry-based learning process.

To ensure the instrument's reliability, Cronbach's alpha was calculated, yielding a value of 0.70, indicating good reliability. This value suggests that the instrument consistently measures the desired variables and is suitable for use in the study. The instrument's validity was also ensured by basing it on well-established numeracy literacy indicators.

As shown in Table 2, the test blueprint is designed to comprehensively assess students' numeracy skills through various types of tasks.

Table 2. Numeracy Literacy Test Blueprint

Basic Competency	Item Indicator	Number of Items
3.6 Explaining data related to students themselves or their surrounding environment and the methods of collecting such data.	Explaining various numbers and data symbols presented	2
	Analyzing various numbers and data symbols presented	2
	Interpreting the results of the analysis to identify numeracy literacy problems	2
	Interpreting the results of the analysis to make decisions	2
4.6 Presenting data related to the students themselves.	Presenting data in the form of a bar chart	2
Total		10

Based on Table 2, the test blueprint was carefully designed to ensure that all important aspects of numeracy literacy are covered. The blueprint aligns with the learning outcomes outlined in the curriculum, including understanding and interpreting data, analysing numerical relations, and presenting data visually. The distribution of items ensures that students are tested on a wide range of numeracy skills, from basic calculation to more advanced data presentation. As shown in Table 3, the scoring guide provides a structured framework for assessing the quality of students' responses to essay-type questions.

Table 3. Numeracy Literacy Ability Scoring Guide

Student responses to questions	Score
The answer is completely correct, clear, comprehensive, and fully aligned with the assessed concept.	4
The answer is correct but slightly incomplete or contains minor errors that do not affect the main understanding.	3
The answer demonstrates partial understanding but includes significant errors or omissions.	2
The answer is mostly incorrect and shows very limited understanding of the concept.	1
No answer is provided or the response is completely irrelevant to the question.	0

As shown in Table 3, this scoring guide is used to evaluate the quality of student responses to essay-type questions. Responses are evaluated based on their correctness, clarity, and alignment with the concept being assessed. A score of 4 indicates a fully correct and well-explained answer, while a score of 0 reflects an irrelevant or missing response. This rubric ensures consistency and fairness in scoring, allowing for a reliable assessment of numeracy literacy across all students.

Data Analysis

Data analysis was conducted in stages to ensure that the research results were accurate and could be interpreted scientifically (Situmeang, 2025). The first stage involved descriptive statistical analysis, including the mean, standard deviation, maximum, and minimum values, to describe the distribution of pretest and posttest scores (Gandur et al., 2025). The second stage was a normality test using the Shapiro-Wilk test to determine whether the data followed a normal distribution (Karima et al., 2024). Improvement in numeracy literacy skills was analysed using the N-Gain calculation to determine the effectiveness of the learning process. Additionally, the Pearson Product-Moment correlation test was used to examine the consistency of the relationship between pretest and posttest scores for individual students, rather than testing the causal relationships between variables (Sihombing et al., 2025).

RESULT

This study presents empirical findings on the improvements in students' numeracy literacy skills following the implementation of the inquiry-based learning model developed in this research. The analysis was conducted systematically to ensure that each conclusion is supported by statistical procedures, in accordance with quantitative research standards. The presentation of the results includes descriptive analysis, normality testing, difference testing, N-Gain analysis, and correlation testing. Each of these analyses contributes to understanding the overall effectiveness of the intervention in enhancing numeracy literacy. Table 4 presents the descriptive statistics for students' numeracy literacy scores before and after the intervention, showing trends in student achievement. These data provide an initial overview of students' performance across both the pretest and posttest.

Table 4. Results of the Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
Pretest	30	55.00	65.00	59.7667	2.78770
Posttest	30	76.00	89.00	82.5333	3.53049
Valid N (listwise)	30				

The data in Table 4 clearly indicate an improvement in learning outcomes following the application of the inquiry-based learning intervention. The average pretest score was 59.77, while the posttest score increased to 82.53, showing a meaningful gain. This improvement is reflected across the entire sample group, with scores indicating a consistent upward trend. The relatively stable score distribution for both the pretest and posttest also suggests that the improvement was not concentrated in a few students, but rather occurred consistently across the entire group of participants. These findings provide initial evidence that the implemented learning model contributed positively to the numeracy literacy outcomes of the students involved in the study.

To ensure the data met the assumptions for parametric tests, a normality test was conducted on the pretest and posttest scores. The results of the normality tests presented in Table 5 confirm that the data follow a normal distribution, which is essential for subsequent statistical analyses.

Table 5. Results of the Normality Test

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Pretest	.104	30	.200*	.968	30	.496
Posttest	.097	30	.200*	.974	30	.647

The significance values for both the pretest (p = 0.496) and posttest (p = 0.647) are greater than 0.05, indicating that the data are normally distributed. This result confirms that the assumptions for parametric analysis have been met, allowing for a valid interpretation of the subsequent statistical tests. The normal distribution of the data provides a solid foundation for conducting parametric analyses, ensuring that the conclusions drawn from the tests are reliable and scientifically sound.

Following confirmation of normality, a paired-samples t-test was performed to assess whether the observed improvement in students' numeracy literacy was statistically significant. The t-test compares the pretest and posttest scores to determine if the change in students' performance is meaningful and not due to random chance. The results of this analysis are summarised in Table 6.

Table 6. Results of the Paired Samples Test

	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
				Lower	Upper			
Pretest - Posttest	-22.766	.858	.156	-23.087	-22.446	-145.275	29	.000

The paired-samples t-test yielded a t-value of −145.275 and a p-value of 0.000 ($p < 0.05$), indicating that the difference between the pretest and posttest scores is statistically significant. The negative t-value and small p-value confirm that the observed improvement is unlikely to be due to random variation. This finding underscores the effectiveness of the inquiry-based learning intervention in significantly improving students' numeracy literacy skills. The large t-value further suggests that the improvement was consistent across most students, reinforcing the reliability of the results.

The N-Gain analysis was conducted to evaluate the intervention's effectiveness, accounting for students' initial abilities. The N-Gain score measures the improvement in students' performance relative to their baseline pretest scores. A higher N-Gain indicates a greater improvement. The summary of the N-Gain results is presented in Table 7.

Table 7. Results of the N-Gain Test

	N	Minimum	Maximum	Mean	Std. Deviation
Ngain_Score	30	.62	1.00	.7881	.10280
Ngain_Persen	30	54.97	89.00	70.1405	9.14914
Valid N (listwise)	30				

The average N-Gain score of 0.788 falls within the 'great improvement' category, indicating that the intervention had a strong, positive effect on students' numeracy literacy skills. The relatively narrow range of N-Gain values, from 0.62 to 1.00, further suggests that the improvement was consistent across students and did not show large disparities. In the context of numeracy skills, an N-Gain value of 0.788 means that, on average, students experienced substantial improvement in their numeracy literacy, demonstrating that the inquiry-based learning model was highly effective in promoting learning gains. This N-Gain score reflects both the relative improvement from baseline and the intervention's high effectiveness.

Lastly, a Pearson correlation analysis was conducted to assess the relationship between the pretest and posttest scores. The correlation coefficient measures the strength and direction of the linear relationship between these two variables, indicating the consistency of students' performance over time. The results are presented in Table 8.

Table 8. Results of the Correlation

		Pretest	Posttest
Pretest	Pearson Correlation	1	.991**
	Sig. (2-tailed)		.000
	N	30	30
Posttest	Pearson Correlation	.991**	1
	Sig. (2-tailed)	.000	
	N	30	30

The Pearson correlation coefficient of 0.991, with a p-value of 0.000 (< 0.05), indicates a very strong positive relationship between the pretest and posttest scores. This result suggests that students' progress from the pretest to the posttest was consistent across initial ability levels. The strong correlation indicates that the improvement in numeracy literacy was sustained across the group, with both high- and low-achieving students showing similar patterns of progress. This consistency supports the reliability of the findings and further reinforces the effectiveness of the inquiry-based learning intervention. The very high correlation suggests that the intervention led to a stable, reliable improvement across all students.

DISCUSSION

This study found that implementing the inquiry-based learning model significantly improves elementary school students' numeracy literacy skills because students are more engaged in exploring problems and reflecting on their own understanding (Yaqin, 2024). The inquiry-based learning model allows students to build conceptual understanding through active investigation, thereby strengthening their numerical understanding compared to conventional learning methods (Sriyono et al., 2024). Additionally, other research also shows that inquiry-based approaches can simultaneously improve numeracy and literacy skills through innovatively designed learning media (Rahayu & Subekti, 2025). This suggests that active learning could be one solution to address low basic skills in elementary schools (Yaqin, 2024).

The significant increase in posttest scores relative to pretest scores indicates that students experienced meaningful learning gains after implementing the inquiry-based learning model. The paired-samples t-test results confirm that this improvement is statistically significant and not due to random variation. This finding shows that inquiry-based learning supports students in understanding numerical concepts more deeply through active engagement and problem exploration (Mediana et al., 2025). Consequently, students are better able to apply mathematical reasoning to solve contextual problems presented during the learning process (Doz et al., 2025).

Theoretically, these results are consistent with educational scholars who argue that the inquiry-based learning model provides students with space to develop the critical thinking and problem-solving skills necessary for numeracy literacy (Bhoke, 2024). The inquiry-based learning process encourages students to formulate questions, gather and analyse information independently, thereby strengthening their conceptual understanding of

numerics (Sektiwulan et al., 2024). Other studies also show that active student involvement in inquiry can improve reflective thinking skills in real-world contexts. Thus, the inquiry-based learning model not only improves procedural learning outcomes but also supports deeper cognitive development (Susanta et al., 2025).

The effectiveness of the inquiry-based learning model is further supported by the high N-Gain value obtained in this study. A high N-Gain score indicates that students experienced substantial improvement relative to their initial abilities. This result suggests that inquiry-based learning facilitates meaningful learning by encouraging students to connect mathematical concepts with real-life situations. As a result, students develop a more flexible understanding of numeracy rather than relying solely on memorisation (Riwanda & Nindiasari, 2025).

The correlation between pretest and posttest scores shows consistency in individual students' achievement after the learning model was applied, both for students with high and low initial abilities (Yaqin, 2024). These findings suggest that the inquiry-based learning model can maintain students' learning achievement patterns across diverse ability levels (Huda et al., 2022). The exceptionally strong Pearson correlation complements the N-Gain findings by demonstrating the stability of the intervention's impact. While the N-Gain analysis directly measures the magnitude of improvement, this correlation confirms that the inquiry-based model works systematically across the entire group. It indicates that the progress was not skewed by specific outliers, but rather facilitated a uniform growth in competence for all students, regardless of their initial ability levels. This suggests that the inquiry model is an inclusive pedagogical tool, providing equal opportunities for both high- and low-achieving students to enhance their numeracy literacy skills.

Additionally, this approach supports the development of critical thinking skills, which are essential for 21st-century education, particularly in solving complex mathematical problems (Gombo, 2025). Therefore, the inquiry-based learning model can be considered effective in facilitating numeracy literacy development in heterogeneous classroom environments (Alhusna et al., 2025). Beyond its academic impact, the inquiry-based learning model has important implications for teaching practices in elementary schools because it provides students with space to explore knowledge independently and collaboratively (Ashari, 2025). Through inquiry activities, students are encouraged to actively participate in discussions and problem-solving tasks. Other studies have shown that inquiry-based media, such as educational games, effectively improve students' literacy and numeracy through engaging, context-rich learning experiences (Kirom & Aini, 2023). This indicates that inquiry-based learning can enhance both learning outcomes and student motivation.

However, several limitations should be considered when interpreting the results of this study. The use of a pre-experimental design without a control group limits the strength of causal conclusions that can be drawn from the findings. In addition, the relatively small sample size restricts the generalizability of the results to broader student populations. Therefore, future research is recommended to employ experimental or quasi-experimental designs with larger samples and control groups to further validate the effectiveness of inquiry-based learning in improving numeracy literacy.

CONCLUSION

Based on the research findings, the inquiry-based learning model is highly effective in improving elementary school students' numeracy literacy skills. The significant improvement

from the initial assessment to the final evaluation, supported by substantial effectiveness gains, indicates that this learning approach effectively enhances students' understanding of numerical concepts, logical reasoning, and contextual problem-solving. A deeper analysis of the Pearson correlation reveals that the intervention provides a consistent impact across the entire student group. This strong relationship suggests that the progress made was not fragmented; instead, the inquiry model facilitated stable, uniform growth in competence, regardless of students' initial ability levels. Consequently, the model is proven to be a reliable pedagogical tool for fostering active engagement and deeper cognitive development in numeracy. However, the limitations of the pre-experimental design in this study provide opportunities for future research to employ true experimental designs with control groups and larger sample sizes to further strengthen the generalizability of these findings.

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