



## Effectiveness of guided inquiry learning and self-regulated learning on students' numeracy skills

Mahsup<sup>\*1</sup>, Syaharudin<sup>2</sup>, Matthew Nepomuceno<sup>3</sup>, Hasan bin Jali<sup>4</sup>

<sup>1</sup>Universitas Muhammadiyah Mataram, Mataram, Indonesia; [mahsup.math@gamil.com](mailto:mahsup.math@gamil.com)

<sup>2</sup>Universitas Muhammadiyah Mataram, Indonesia; [syahrudin.ntb@gmail.com](mailto:syahrudin.ntb@gmail.com)

<sup>3</sup>Far Eastern University, Manila, Philippines; [matthew.nepomuceno@feu.edu.ph](mailto:matthew.nepomuceno@feu.edu.ph)

<sup>4</sup>University of Kuala Lumpur, Kuala Lumpur, Malaysia; [hasanjali@utm.my](mailto:hasanjali@utm.my)

<sup>\*</sup>Corresponding author: Mahsup; E-mail addresses: [mahsup.math@gamil.com](mailto:mahsup.math@gamil.com)

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**Abstract.** Numeracy is a fundamental competency for university students, particularly in education-related programs. However, evidence shows that numeracy performance in Indonesia remains relatively low, highlighting the urgency of identifying effective instructional and learner-related factors that support numeracy development in higher education. Previous studies have often examined instructional approaches and learner characteristics separately, resulting in a limited understanding of their combined influence at the tertiary level. Therefore, this study aims to examine the influence of guided inquiry learning and self-regulated learning on students' numeracy skills. Using a quantitative correlational design, data were collected from 50 undergraduate students purposively selected from the Mathematics Education and Elementary Teacher Education programs. The inclusion criteria focused on students who had completed courses related to instructional strategies and mathematical reasoning. Data were obtained through validated Likert-scale questionnaires and analyzed using multiple linear regression. The results show that guided inquiry learning and self-regulated learning significantly predict numeracy skills ( $F = 96.923, p < .001$ ). These findings indicate that numeracy development becomes more effective when inquiry-oriented instruction is supported by strong self-regulated learning capacities. Accordingly, this study recommends integrating guided inquiry learning with self-regulated learning strategies to strengthen numeracy competencies in higher education.

## Introduction

Numeracy is a fundamental competency that university students must possess in today's data-driven era, encompassing not only basic mathematical operations but also the ability to understand, evaluate, and apply quantitative information in both academic and practical decision-making. In higher education, numeracy plays a crucial role in shaping students' analytical thinking and problem-solving skills, particularly in programs that require data processing and mathematical reasoning (Purnadewi & Widana, 2023). Recent studies highlight that the increasing complexity of information in the digital era demands strong numeracy competencies, including the ability to interpret graphs, analyze statistics, and evaluate data-based arguments (Goos, 2022). Other research reports that low numeracy often hinders students' ability to engage effectively in analytical coursework, ultimately affecting overall academic performance (Saha et al., 2024). Furthermore, numeracy has become a key indicator of students' readiness to meet workforce demands, as many

professional fields are placing greater emphasis on quantitative competence (Fitri et al., 2024). In higher education, strengthening numeracy is therefore a strategic priority to ensure that students can adapt and participate effectively in increasingly data-oriented academic and professional environments (Quainoo et al., 2025).

Guided inquiry learning is a pedagogical approach that positions students at the center of learning through exploration, questioning, investigation, and drawing conclusions with structured instructional support from lecturers (Widana & Ratnaya, 2021). This approach has been shown to enhance analytical abilities, reasoning, and conceptual understanding by enabling students to engage directly in meaningful investigative processes (Yu, 2024). The effectiveness of guided inquiry learning, however, does not solely depend on instructional design but is also influenced by students' ability to actively manage their own learning processes. Self-regulated learning (SRL), which involves goal setting, monitoring comprehension, and managing learning strategies, is a key factor contributing to academic success at the tertiary level (Caixia et al., 2025). Recent studies affirm that students with high SRL are more capable of utilizing active learning strategies, including inquiry-based learning, leading to improved mastery of higher-order cognitive skills (Antonio & Effects, 2024). Moreover, integrating guided inquiry learning with SRL is believed to create a more effective learning environment, as students receive necessary pedagogical guidance while simultaneously managing their learning independently (Dan et al., 2025). This integration is particularly relevant for numeracy development, which inherently requires sustained reasoning, reflection, and independent problem-solving.

Empirical findings in Indonesian higher education indicate that students' numeracy levels remain at a stage requiring serious attention. Numerous studies show that students frequently struggle with numeracy tasks that require logical reasoning, graph interpretation, and the application of mathematical concepts to contextual problems. Recent research found that more than half of first-year university students experienced difficulties in reading data representations and performing basic quantitative analyses, especially when tasks involved graphs or statistical tables (Setiawan & Sukoco, 2021). Research on guided inquiry at the secondary level, for instance, found that the learning model significantly influenced students' mathematical numeracy performance, explaining up to 77.7% of the variance in numeracy outcomes (Wiyata & Suwartini, 2022). Recent evidence from Indonesian higher education contexts also shows that students' reasoning and numeracy-related competencies remain below expected standards, with many still struggling to interpret data representations and justify mathematical arguments (Díezpalomar et al., 2023). Additional national findings indicate that innovations in mathematics instruction often focus on improving general mathematical achievement rather than specifically addressing numeracy development at the university level, leaving a gap in targeted numeracy interventions (Hasan, 2023). Furthermore, universities in Southeast Asia have documented significant numeracy gaps between early-semester and late-semester students, calling for more systematic pedagogical reforms to strengthen mathematical reasoning (Kattoum et al., 2023). These conditions underscore the urgency of developing effective instructional strategies to address low numeracy performance in higher education.

One pedagogical approach widely explored for developing students' higher-order thinking skills is guided inquiry learning. This approach positions students as active investigators who formulate questions, construct hypotheses, analyze information, and draw conclusions systematically. Recent evidence suggests that guided inquiry significantly enhances reasoning and data-based argumentation skills among STEM students. Evidence from quasi-experimental research demonstrates that guided inquiry combined with metacognitive strategies can substantially improve students' problem-solving and problem-posing abilities, particularly in tasks requiring structured reasoning. Another study found that guided inquiry implementation increased the accuracy of

mathematical concept comprehension by up to 27% in experimental groups. A recent meta-analysis further supports the effectiveness of guided inquiry, showing consistent improvements in students' creative and analytical thinking abilities, particularly within mathematics learning environments. However, most of these studies have focused on critical thinking or conceptual understanding, while investigations specifically examining the effect of guided inquiry on university students' numeracy skills remain limited and are often conducted at the elementary or secondary level. Additionally, research by indicates that guided inquiry can enhance quantitative problem-solving skills, yet few studies link this effect with internal learner factors such as self-regulated learning. This literature gap provides a strong rationale for further examining how guided inquiry learning contributes to numeracy development in higher education (Evi Yupani & Widana, 2023).

Previous studies have demonstrated that guided inquiry learning can enhance students' higher-order thinking skills, including reasoning and data-based argumentation by positioning learners as active investigators who formulate questions, construct hypotheses, analyze information, and draw conclusions systematically (Fielding, 2025; Divrik, 2023; Cahaya et al., 2024). Empirical evidence from quasi-experimental studies shows that guided inquiry, particularly when combined with metacognitive strategies, significantly improves structured problem-solving and problem-posing abilities, while other studies report increased accuracy in mathematical concept comprehension within inquiry-based classrooms (Utaminingsih et al., 2022). Despite these positive findings, most existing research has emphasized outcomes such as critical thinking, conceptual understanding, and general problem-solving skills rather than numeracy as a distinct learning outcome, especially at the university level (Ogunjimi & Gbadeyanka, 2023). Moreover, although guided inquiry has been shown to enhance quantitative problem-solving skills, few studies explicitly connect these effects with internal learner characteristics, such as self-regulated learning (Ambaryani et al., 2022). Similarly, research on self-regulated learning predominantly focuses on overall academic achievement or general mathematics performance, without directly addressing its role in developing numeracy competencies, including quantitative reasoning and representation interpretation. Consequently, the combined role of guided inquiry learning and self-regulated learning in shaping university students' numeracy skills remains underexplored, highlighting a clear research gap that warrants further investigation in higher education contexts.

Beyond instructional strategy, internal learner factors such as self-regulated learning (SRL) also play a critical role in supporting numeracy development and academic achievement. Students with high SRL tend to plan their learning activities independently, manage time effectively, select appropriate learning strategies, and access additional learning resources to strengthen their understanding of quantitative material. Empirical evidence shows that SRL significantly contributes to academic performance; for instance, among students in mathematics education, SRL was found to positively correlate with learning outcomes even under online learning conditions (Xu et al., 2023). Another study revealed that SRL is associated with improved mathematical problem-solving and logical reasoning, both of which are components of numeracy (Kurniawan et al., 2023). A study in a mobile-technology-integrated mathematics classroom found that metacognitive self-regulation and rehearsal strategies served as significant predictors of students' mathematics performance, with a predictive accuracy of approximately 68.5% (Ramos et al., 2023). More recent findings also indicate that inquiry-based learning supported by digital tools can significantly enhance conceptual understanding of mathematics, suggesting that students' self-regulation capacities may interact with inquiry processes to influence numeracy-related outcomes (Juniantari et al., 2025). These findings underscore that SRL is not only linked to general academic outcomes but may also enhance skills closely related to numeracy, such as reasoning, representation interpretation, and problem-solving. Therefore, integrating guided inquiry with SRL development becomes essential for strengthening numeracy competencies in higher education environments. Additionally, a survey of Mathematics Education students reported that most students fell within the "moderate" category of SRL, with

24.1% categorized as low, indicating that self-regulated learning practices are not yet fully optimal (Yunitasari et al., 2024). These findings reinforce the notion that SRL may act as a mediating or moderating factor in enhancing numeracy through active learning approaches such as guided inquiry. Hence, integrating innovative instructional strategies with the development of self-regulated learning should receive substantial attention in the design of higher education learning environments.

A review of prior studies reveals a clear research gap in the development of numeracy skills within higher education. The existing literature predominantly examines guided inquiry learning or self-regulated learning as isolated variables, with most inquiry-based numeracy studies conducted at the primary or secondary education levels, while research at the tertiary level remains limited. Furthermore, studies on self-regulated learning largely focus on general academic achievement or mathematical performance without explicitly addressing numeracy as a distinct competency involving quantitative reasoning, data interpretation, and representation skills. Consequently, empirical evidence that investigates the combined influence of guided inquiry learning and self-regulated learning on university students' numeracy skills is exceedingly scarce. The novelty of the present study lies in its integrated analytical approach, which simultaneously examines guided inquiry learning and self-regulated learning as complementary predictors of numeracy competence. Unlike previous studies that emphasize single instructional models or learner characteristics, this research offers a more comprehensive perspective by capturing the interaction between pedagogical design and learner autonomy in shaping numeracy development in higher education contexts.

Based on this identified gap, the present study is designed to address the following research problem: to what extent do guided inquiry learning and self-regulated learning individually and jointly influence university students' numeracy skills? Accordingly, this study aims to examine the effectiveness of guided inquiry learning and self-regulated learning in enhancing numeracy competence among university students. The hypotheses formulated in this study are as follows: (1) guided inquiry learning has a significant positive effect on students' numeracy skills; (2) self-regulated learning has a significant positive effect on students' numeracy skills; and (3) guided inquiry learning and self-regulated learning simultaneously serve as significant predictors of students' numeracy performance. By clarifying these relationships, this study is expected to contribute theoretically to the refinement of numeracy-oriented learning frameworks and practically to the development of more effective, student-centered instructional strategies and policy directions in higher education.

## Method

### Research Design and Approach

This study employed a quantitative correlational research design to examine the relationship and predictive influence of guided inquiry learning and self-regulated learning on students' numeracy skills. A correlational approach was considered appropriate for identifying the strength and direction of associations among educational variables without manipulating the learning environment, in line with recommendations from contemporary empirical research (Changjun & Xiaowen, 2025).

### Research Setting and Timeline

The research was conducted at the Mathematics Education and Elementary Teacher Education programs of Universitas Muhammadiyah Mataram during the 2025 academic year. These programs were selected for their strong relevance to numerical reasoning, data literacy, and inquiry-based pedagogy in higher education.

### Participants and Sampling Technique

The population consisted of all active undergraduate students enrolled in the Mathematics Education and Elementary Teacher Education programs. The sample was obtained through purposive sampling, with inclusion criteria requiring students to have completed courses in instructional strategies and mathematical reasoning. To ensure sufficient academic exposure, only students in their third semester or above were included. Purposive sampling was applied because it allows the selection of participants whose learning experiences align with the variables under investigation, as is commonly practiced in educational measurement research (Ahmad & Wilkins, 2024). A total of 50 students met these criteria and participated in the study.

### Data Collection Techniques and Research Instruments

Data were collected using a digital questionnaire distributed through an online survey platform to ensure accessibility and efficiency. Online data collection has been recognized as an effective method in educational research, particularly for reaching diverse student populations (Peimani, 2021). The questionnaire consisted of three sections, measuring: (1) guided inquiry learning, (2) self-regulated learning, and (3) numeracy skills. All items were rated on a 5-point Likert scale from 1 (strongly disagree) to 5 (strongly agree). The items were developed based on established theoretical constructs and indicators derived from recent literature. Each construct was operationalized using multiple indicators reflecting cognitive, behavioral, and instructional dimensions relevant to the variables studied.

### Instrument Validity and Reliability Tests

Content validity was evaluated by three experts in mathematics education and educational assessment to ensure conceptual relevance, clarity, and alignment with research objectives. Revisions were made based on expert feedback. A pilot test was conducted with a small group of students outside the main sample to assess instrument clarity and reliability. Instrument reliability was assessed using Cronbach's Alpha, with a minimum acceptable coefficient of  $\geq 0.70$ , consistent with contemporary standards for educational measurement (Izah et al., 2024). All instruments met the reliability criteria and were deemed suitable for data collection.

### Research Procedure

The research procedure was conducted through several systematic stages, including instrument development, expert validation, pilot testing, data collection, data tabulation, and data analysis. The sequence of these procedures is illustrated in Image 1.

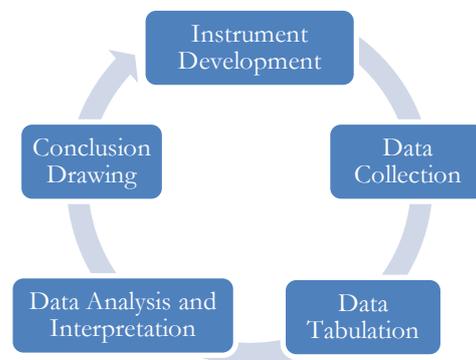


Image 1. Research Procedure

As shown in Image 1, the procedure began with the development and validation of the research instrument to ensure conceptual and technical accuracy. After finalizing the instrument, data were collected through an online questionnaire administered to participants from both study programs.

The collected responses were then tabulated and organized to facilitate statistical analysis. Subsequent stages included descriptive statistical analysis and multiple linear regression to examine the predictive effects of guided inquiry learning and self-regulated learning on numeracy skills. The final stage involved synthesizing the results to draw conclusions aligned with the research objectives.

### Data Analysis Techniques and Criteria

Data analysis consisted of descriptive and inferential statistical techniques. Descriptive statistics were used to summarize the minimum, maximum, mean, and standard deviation of each variable. Inferential analysis was performed using multiple linear regression to determine the predictive effects of guided inquiry learning and self-regulated learning on students' numeracy skills. The analysis was conducted using JASP and SPSS (latest version), a statistical software recommended for transparent and reproducible educational research (Dablander et al., 2021). Prior to regression analysis, classical assumption tests for normality, linearity, multicollinearity, and heteroscedasticity were conducted to ensure the validity of the regression model. Statistical significance was determined at the 0.05 level ( $\alpha = 0.05$ ). Regression coefficients were interpreted to assess the direction and magnitude of predictive relationships, and hypothesis-testing decisions were based on comparisons between the obtained p-values and the predetermined significance level.

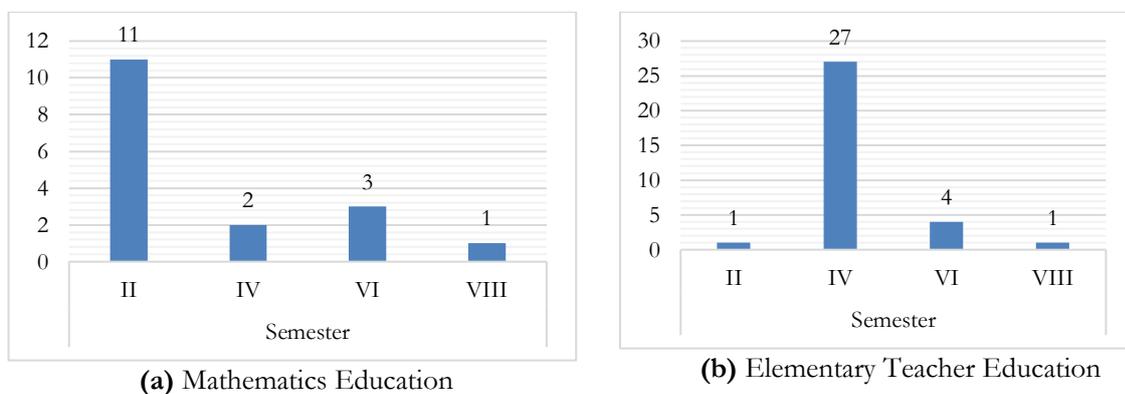
### Ethical Considerations

Ethical considerations were addressed throughout the research process. Participation was voluntary, and respondents were informed of the study's purpose, confidentiality procedures, and that data would be used solely for academic purposes. Informed consent was obtained prior to participation. No identifying personal information was collected, and all data were handled in accordance with ethical standards for educational research.

## Results and Discussion

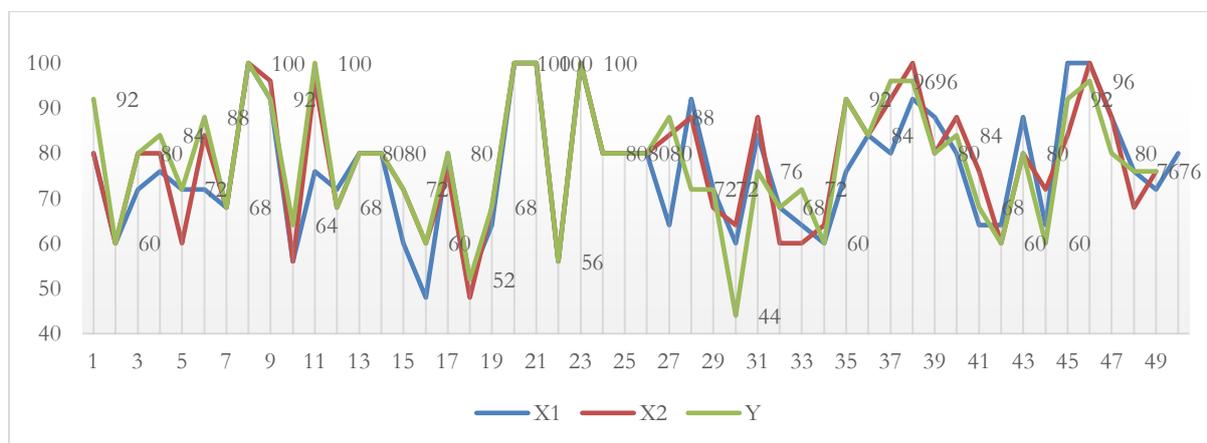
### Respondent Characteristics and Preliminary Data Patterns

A total of 50 respondents participated in this study, and all completed the questionnaire in full, allowing the dataset to be analyzed without any missing responses. The respondents comprised 17 students from the Mathematics Education Study Program and 33 from the Elementary Teacher Education Study Program. These two programs were selected due to their direct relevance to numeracy competence and inquiry-based learning in higher education. To provide contextual information regarding respondents' academic experience, their distribution across semester levels in both study programs is presented in Image 2.



**Image 2.** Distribution of Respondents from the Mathematics Education and Elementary Teacher Education Study Programs

Image 2 illustrates the distribution of respondents across semester levels in the Mathematics Education and Elementary Teacher Education study programs, revealing distinct academic profiles between the two groups. In the Mathematics Education program, the majority of respondents were concentrated in the second semester (11 students), followed by a substantially smaller number in the fourth (2 students), sixth (3 students), and eighth semesters (1 student). This pattern indicates that most Mathematics Education respondents were at an early stage of their academic journey, where foundational competencies, including numeracy skills and self-regulated learning strategies, are still developing, and instructional guidance remains highly influential. In contrast, respondents from the Elementary Teacher Education program were predominantly enrolled in the fourth semester (27 students), with limited representation in the second (1 student), sixth (4 students), and eighth (1 student) semesters. This distribution reflects a participant profile with more mature academic experience and greater exposure to diverse instructional approaches, including inquiry-based learning and reflective practices. These differences in semester composition provide important contextual information for interpreting the study's findings, as variations in academic experience and learning autonomy may influence levels of guided inquiry learning, self-regulated learning, and numeracy skills. Following this descriptive analysis of respondent characteristics, the next section examines preliminary patterns among the main research variables, which are visually presented in Image 3.



**Image 3.** Distribution of Student Respondents from the Mathematics Education and Elementary Teacher Education Programs

Image 3 illustrates the fluctuation patterns of guided inquiry learning (X1), self-regulated learning (X2), and students' numeracy skills (Y) across all 50 respondents. The three variables show dynamic variation, with scores ranging from 44 to 100, indicating heterogeneous levels of inquiry engagement, learner autonomy, and numeracy performance. Visually, X1 and X2 exhibit largely parallel movements across respondents, while numeracy scores tend to follow a similar trajectory, with several students reaching the maximum score of 100. Periods of higher guided inquiry and self-regulated learning are generally associated with higher numeracy scores, whereas decreases in both predictors are associated with lower numeracy outcomes. Although these visual patterns do not imply causality, they provide preliminary descriptive evidence of a positive association among the variables.

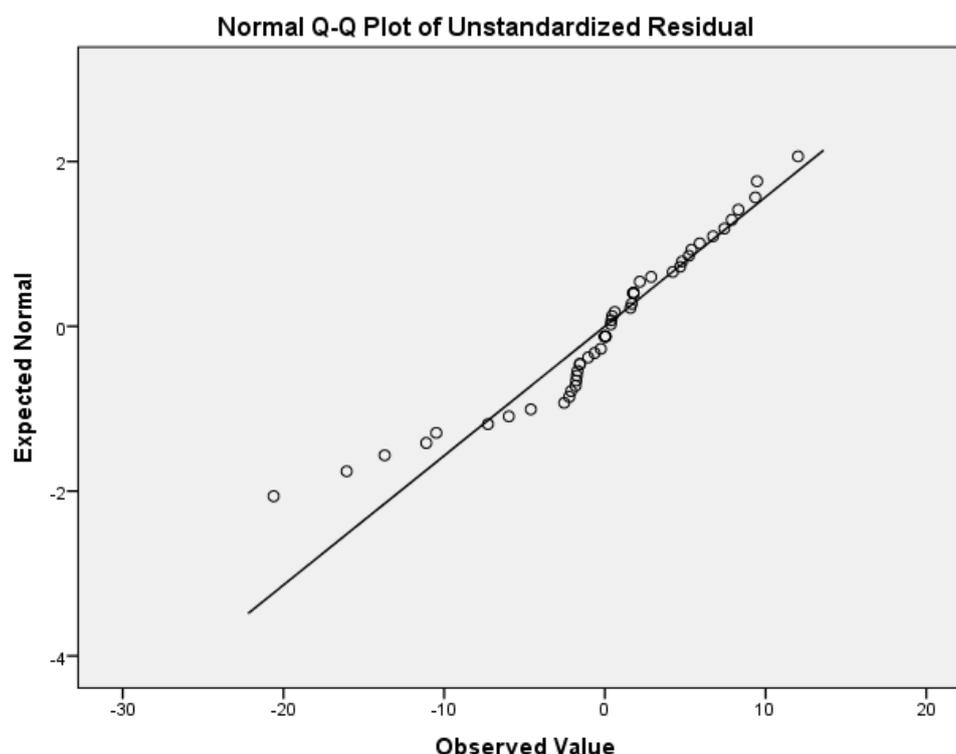
### Assumption Tests for Multiple Linear Regression

Before performing multiple linear regression analysis, several classical assumption tests were conducted to ensure that the data met the statistical requirements for regression modeling. These tests included normality, homogeneity, linearity, and multicollinearity. Meeting these assumptions is essential to obtain unbiased and reliable regression estimates.

## Normality Test

**Table 1.** Results of Normality Tests for Research Variables and Regression Residuals

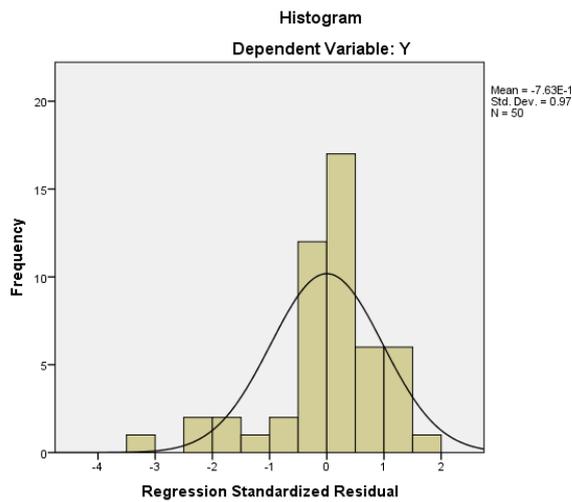
	Kolmogorov-Smirnov <sup>a</sup>			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
X1	.114	50	.106	.962	50	.107
X2	.131	50	.033	.956	50	.058
Y	.103	50	.200*	.966	50	.157
Unstandardized Residual	.185	50	.000	.919	50	.002



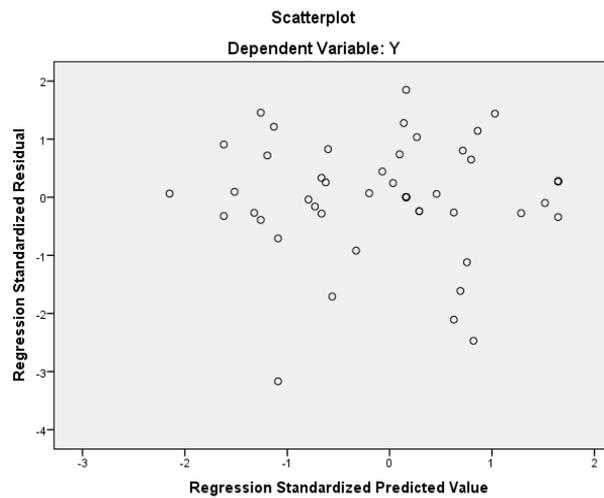
**Image 4.** Normal Q–Q Plot of Unstandardized Regression Residuals

Table 1 presents the results of the Kolmogorov–Smirnov and Shapiro–Wilk normality tests for the independent variables (X1 and X2), the dependent variable (Y), and the unstandardized regression residuals. The results indicate that guided inquiry learning (X1) and self-regulated learning (X2) generally exhibit acceptable normality, with Shapiro–Wilk significance values exceeding the 0.05 threshold. Similarly, numeracy skills (Y) demonstrate a normal distribution, as indicated by non-significant results in both normality tests. In contrast, the unstandardized regression residuals show statistically significant results in both the Kolmogorov–Smirnov test ( $p = 0.000$ ) and the Shapiro–Wilk test ( $p = 0.002$ ), indicating a deviation from perfect normality. However, graphical inspection of the Normal Q–Q Plot in Image 4 reveals that the residual points largely follow the diagonal reference line, with only minor deviations at the lower tail. This pattern suggests that the residual distribution is approximately normal. Given the moderate sample size ( $n = 50$ ), regression analysis is considered robust to minor violations of the normality assumption, particularly when supported by visual evidence from the Q–Q plot. Therefore, the residual distribution was deemed sufficiently normal for multiple linear regression analysis.

## Homogeneity of Variance (Homoscedasticity Test)



**Image 5.** Histogram of Standardized Regression Residuals



**Image 6.** Scatterplot of Standardized Residuals versus Standardized Predicted Values

Image 5 illustrates the distribution of standardized regression residuals for the dependent variable (numeracy skills). The histogram shows a relatively symmetric distribution centered on zero, indicating that the residuals are evenly distributed and not excessively skewed. This pattern supports the assumption that the residual variance is stable and does not exhibit abnormal concentration at particular values. Image 6 presents a scatterplot of standardized residuals plotted against standardized predicted values. The residuals appear randomly distributed along the horizontal axis, with no discernible funnel shape, curvature, or systematic pattern. This random distribution indicates that the variance of residuals remains relatively constant across different levels of predicted numeracy scores. The absence of heteroscedasticity suggests that the homoscedasticity assumption holds. Taken together, the histogram and scatterplot provide complementary visual evidence that the regression residuals demonstrate homoscedasticity. This finding confirms that the regression model meets the variance-related prerequisite for multiple linear regression analysis.

### Linearity Test

**Table 2.** Linearity Test Results between Guided Inquiry Learning (X1) and Numeracy Skills (Y)

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups (Combined)	7005.600	12	583.800	9.082	.000
Linear Term	6061.395	1	6061.395	94.295	.000
Weighted Deviation	944.205	11	85.837	1.335	.245
Within Groups	2378.400	37	64.281		
Total	9384.000	49			

**Table 3.** Linearity Test Results between Self-Regulated Learning (X2) and Numeracy Skills (Y)

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups (Combined)	8508.267	12	709.022	29.956	.000
Linear Term	7297.362	1	7297.362	308.31	.000
Weighted Deviation	1210.905	11	110.082	4.651	.000
Within Groups	875.733	37	23.668		

	Sum of Squares	df	Mean Square	F	Sig.
Total	9384.000	49			

The results of the linearity test between guided inquiry learning (X1) and numeracy skills (Y), as presented in Table 2, show that the linear component is statistically significant ( $p = .000$ ), while the deviation from linearity is not significant ( $p = .245 > .05$ ). This indicates that the relationship between guided inquiry learning and numeracy skills follows a linear pattern and fully satisfies the linearity assumption required for multiple regression analysis. In contrast, the linearity test results for the relationship between self-regulated learning (X2) and numeracy skills (Y), presented in Table 3, reveal that the linear component is statistically significant ( $p = .000$ ); however, the deviation from linearity is also statistically significant ( $p = .000 < .05$ ). This finding suggests that although a strong linear trend exists, the relationship between self-regulated learning and numeracy skills also exhibits a significant non-linear component. Therefore, the linearity assumption for X2 is only partially met. Overall, these results indicate that guided inquiry learning demonstrates a clear linear relationship with numeracy skills, whereas the relationship between self-regulated learning and numeracy skills is more complex and may not be fully captured by a purely linear model.

### **Multicollinearity Test**

**Table 4.** Multicollinearity Test Results Using Tolerance and Variance Inflation Factor (VIF)

Model	Unstandardized Coefficients		Standardized Coefficients		t	Sig.	Collinearity Statistics	
	B	Std. Error	Beta				Tolerance	VIF
1 (Constant)	7.043	5.494			1.282	.206		
X1	.197	.129	.195		1.528	.133	.277	3.607
X2	.715	.127	.716		5.617	.000	.277	3.607

Table 4 presents the results of the multicollinearity test based on tolerance and Variance Inflation Factor (VIF) values for both independent variables. The tolerance values for guided inquiry learning (X1) and self-regulated learning (X2) are both 0.277, which exceeds the minimum acceptable threshold of 0.10. In addition, the VIF values for both variables are 3.607, which are well below the commonly accepted cut-off value of 10. These findings indicate that the independent variables do not exhibit problematic multicollinearity and that each variable contributes distinct information to the regression model. The absence of multicollinearity suggests that the regression coefficients can be interpreted reliably, as the effects of guided inquiry learning and self-regulated learning on numeracy skills are not confounded by excessive overlap between the predictors. Consequently, both variables are statistically appropriate for inclusion in the multiple regression analysis. Having confirmed that the assumptions of normality, homogeneity, linearity, and multicollinearity were adequately satisfied, the analysis proceeded to multiple linear regression. This regression analysis examined both the individual and combined effects of guided inquiry learning and self-regulated learning on students' numeracy skills. The results of the multiple regression analysis are presented and discussed in the following section.

### **Multiple Regression Results**

**Table 5.** Results of the Multiple Linear Regression Analysis

Model		Sum of Squares	Df	Mean Square	F	p
M <sub>1</sub>	Regression	7,554,552	2	3,777,276	96.923	< .001
	Residual	1,792,713	46	38.972		
	Total	9,347,265	48			

Table 5 presents the results of the multiple linear regression analysis assessing the joint contribution of guided inquiry learning and self-regulated learning to students' numeracy skills. The analysis shows that the regression model explains a substantial portion of the variability in numeracy scores, with a Regression Sum of Squares of 7,554,552 across two degrees of freedom and a corresponding Mean Square of 3,777,276. In contrast, the Residual Sum of Squares is 1,792,713 with 46 degrees of freedom, representing the variance in numeracy skills not accounted for by the two predictors. The Total Sum of Squares of 9,347,265 reflects the overall variation in numeracy performance among respondents. The resulting F-statistic of 96.923 is statistically significant at  $p < .001$ , indicating that the regression model as a whole provides a significantly better fit than a null model without predictors. This finding confirms that guided inquiry learning and self-regulated learning, when considered simultaneously, have a statistically significant combined effect on students' numeracy skills. Moreover, the relatively large proportion of explained variance compared to the unexplained residual variance suggests that these two instructional and learner-related factors play an important role in shaping numeracy performance, although other unmodeled factors, such as prior mathematical ability, learning experiences, or individual cognitive differences, may also contribute. Overall, the significant regression model provides strong empirical support for the proposed analytical framework and justifies further interpretation of the individual regression coefficients to determine each independent variable's relative contribution.

### **Predictive Relationships and Educational Implications of Guided Inquiry and Self-Regulated Learning on Numeracy Skills**

The results of the multiple regression analysis indicate that guided inquiry learning ( $X_1$ ) and self-regulated learning ( $X_2$ ) jointly exert a significant influence on students' numeracy skills ( $Y$ ), as reflected by an F-value of 96.923 ( $p < .001$ ). The substantial proportion of explained variance, evidenced by the large Regression Sum of Squares relative to the Residual Sum of Squares, confirms that the proposed model provides a strong and reliable prediction of numeracy performance. This finding demonstrates that differences in students' engagement with inquiry-based learning activities and their capacity for self-regulation meaningfully account for variations in numeracy outcomes. The positive contribution of guided inquiry learning to numeracy skills is consistent with previous studies that have highlighted the effectiveness of inquiry-based instructional models in mathematics education. [Artuz and Roble \(2021\)](#) demonstrated that Process-Oriented Guided Inquiry Learning significantly enhanced students' mathematical reasoning and mastery levels compared to conventional instructional approaches. Likewise, [Wiyata and Suwartini \(2022\)](#) reported that guided inquiry accounted for a substantial proportion of variance in students' numeracy abilities, indicating that structured investigative learning supports students' capacity to interpret and apply quantitative information. Complementing these findings, [Divrik \(2023\)](#) showed that inquiry-based learning, when integrated with metacognitive strategies, significantly improved students' problem-solving and structured problem-posing abilities, underscoring the role of inquiry in strengthening higher-order cognitive processes. Collectively, these studies reinforce the present findings by confirming that guided inquiry learning fosters analytical reasoning, mathematical representation, and reflective thinking, all of which are fundamental components of numeracy skills.

Self-regulated learning also emerged as a significant predictor of numeracy skills. Students with stronger self-regulation tend to perform better in numeracy because they are better able to plan, monitor, and evaluate their learning. This result aligns with [Ramos \(2023\)](#), who found that metacognitive self-regulation is a strong predictor of mathematics achievement. In this study, self-regulated learning enables students to independently analyze numerical problems, apply appropriate strategies, and verify solutions, all of which are central to numeracy competence. Importantly, the findings indicate that numeracy skills are most effectively developed when guided inquiry learning is supported by high levels of self-regulated learning. This complementary

relationship suggests that structured inquiry provides cognitive guidance, while self-regulation allows students to internalize and manage the learning process. Similar interaction patterns were reported by Rahmawati (2025), who found that students with high learning independence benefited most from inquiry-based mathematics instruction. These results highlight the synergistic role of instructional structure and learner autonomy in supporting numeracy development.

From a theoretical standpoint, this study contributes by empirically integrating guided inquiry learning and self-regulated learning within a single predictive model of numeracy skills, an approach that has been limited in prior research. Practically, the findings underscore the importance of designing learning environments that combine inquiry-oriented tasks with explicit support for students' self-regulatory skills. However, this study is limited by its sample scope and the exclusion of other potential predictors, such as prior mathematical knowledge. Future research is recommended to explore these relationships across broader contexts and incorporate additional variables to further explain numeracy development.

## Conclusion

The findings of this study indicate that guided inquiry learning and self-regulated learning play an important role in strengthening students' numeracy skills by fostering active exploration, analytical reasoning, and autonomous engagement with quantitative information. These two factors work in complementary ways: inquiry-based learning promotes deeper conceptual understanding, and self-regulated learning enables students to manage their strategies, resources, and learning processes more effectively. The results underscore the need for higher education settings to design instructional environments that emphasize not only content mastery but also investigative and reflective learning behaviors that support numeracy development across disciplines. While this study is limited by its relatively small sample and reliance on self-report data, it provides meaningful insight into the pedagogical and learner-related conditions that contribute to improved numeracy competence. Future research is recommended to involve more diverse participant groups and to employ performance-based numeracy assessments, as well as technology-enhanced inquiry models, to generate a more comprehensive understanding of effective approaches to enhancing numeracy in contemporary higher education contexts.

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