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Strengthening Students' Numeracy Literacy Learning Profile at Schools in Thailand through STEM Approach

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Abstract: This research based on community service aims to evaluate the effectiveness of the science, technology, engineering, and mathematics (STEM) approach in strengthening the literacy and numeracy learning profile of students at Eakkapapsasanawich Islamic School Thailand. The research employs a quantitative research approach with a single-group pre-test and post-test control design. The research sample consists of two groups: an experimental group receiving STEM-based instruction and a control group receiving conventional instruction. The total number of students involved in this study is 60, with each group comprising 30 students. Data collection techniques include pre-test and post-test assessments involving literacy and numeracy-related questions relevant to the school curriculum. Data analysis is conducted using descriptive statistical methods and independent t-test to compare test results between the experimental and control groups. The results indicate that students who received instruction with the STEM approach experienced a significant improvement in numeracy literacy compared to those who received conventional instruction. The average scores of the final test in the experimental group were significantly higher than those in the control group. Statistical analysis also reveals a significant difference between the two groups in terms of improvement in numeracy literacy scores. This suggests that the STEM approach is effective in enhancing the literacy and numeracy learning profile of students.

Keywords: *Strengthening profile, literacy, numeracy, STEM.*

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Introduction

Education will always undergo curriculum changes over time that shape the future of the younger generation. Education is not just about transferring knowledge, but also about equipping students with the skills and understanding they need to succeed in life (González-Pérez & Ramírez-Montoya, 2022; Perdana & Suswandari, 2021). In this regard, numeracy literacy becomes one of the most vital aspects (Sitopu et al., 2024). The ability to understand, use, and interpret numerical information is a skill required in various areas of life, from personal finance to professional careers (Lurtz et al., 2021). With strong numeracy literacy, students can become more independent, critical individuals capable of tackling complex challenges in modern society (Mahmud & Pratiwi, 2019). Therefore, integrating numeracy literacy into the education curriculum is a crucial step to ensure that every student has a strong foundation in understanding and managing numerical information, enabling them to become meaningful contributors to sustainable future development.

The issue of numeracy literacy is a serious challenge faced by various countries worldwide, including Thailand. As stated in the NSW Department of Education (2016), High-quality professional development has been shown to enhance teaching effectiveness. According to Hattie, effective teaching is the most significant in-school factor influencing student engagement and outcomes. Teacher contributions account for approximately 20 to 30 percent of the variation in student

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achievement. On average, teachers impact standardized test scores annually, with effect sizes ranging from 0.2 to 0.4. However, some teachers consistently achieve even higher student progress, with yearly effect sizes between 0.5 and 0.6 (Hattie & Yates, 2013).

Well-designed professional learning ensures that all educators perform at their best, leading to improved literacy and numeracy outcomes for students. A 2007 report by the United States Institute of Education Sciences reviewed the effects of professional development on elementary school teachers across various studies, reporting a consistent average effect size of 0.54 in improving student outcomes. Additional research has demonstrated significant improvements in mathematics performance as a result of professional learning (Lindvall, 2017; Scher & O'Reilly, 2009) and in literacy outcomes at both primary and secondary school levels (Jacob et al., 2017).

In the context of globalization and technological advancement, the ability to comprehend, process, and utilize numerical information is becoming increasingly important for individuals to effectively participate in modern society (Grotlüschen et al., 2020). However, many students in various countries face difficulties in numeracy literacy (Iswara et al., 2022). Factors such as inadequate educational resources, ineffective teaching methods, and lack of motivation in learning can be the primary causes of low numeracy literacy rates in some countries, including Thailand.

In Thailand, despite various efforts to improve the quality of education, numeracy literacy issues remain a serious concern. Eakkapapsasanawich Islamic School in Thailand is also not immune to challenges in numeracy literacy. Although the school focuses on Islamic-based education, students' abilities to understand and apply numerical concepts remain crucial. Some of the issues faced by this school include insufficient resources to support mathematics learning, suboptimal teaching methods in conveying numerical concepts, and students' lack of motivation in learning mathematics. Additionally, the limited school environment in terms of facilities and parental support can also be factors influencing the numeracy literacy level of students at Eakkapapsasanawich Islamic School.

Therefore, joint efforts between teachers, school staff, parents, and other stakeholders are needed to address these numeracy literacy issues and ensure that every student has adequate numeracy skills to succeed in life. With the right steps, it is hoped that Eakkapapsasanawich Islamic School can improve its students' numeracy literacy rates and make a better contribution to education in Thailand through STEM.

Essentially, STEM supports numeracy literacy by integrating mathematics with science, technology, and engineering. This interdisciplinary approach, as explained by Baek et al. (2023) that STEM education promotes numeracy literacy by integrating mathematics with science, technology, and engineering. This interdisciplinary approach fosters critical thinking and problem-solving skills essential for numeracy and helps students develop critical thinking and problem-solving skills that are essential in understanding and using numbers. By integrating mathematical concepts with applications in science, technology, and engineering, STEM education creates a learning environment that promotes students' numeracy skills holistically (Roehrig et al., 2021). For example, in STEM projects, students may need to apply mathematical concepts to design technological solutions or analyze scientific data. This allows them to see the relationship between mathematics and its application in real-world contexts, which in turn enhances their understanding of the material and strengthens their numeracy skills. Thus, STEM education plays a key role in promoting numeracy literacy in an integrated and relevant manner.

Efforts to enhance literacy and numeracy profiles through STEM at Eakkapapsasanawich Islamic School are focused on basic mathematical operations, percentages, probability, statistics, and their practical applications. STEM holds significant benefits in strengthening the understanding and application of basic mathematical operations, such as addition, subtraction, multiplication, and division, which are essential skills in various aspects of daily life. For instance, in the context of personal finance management, students can utilize basic mathematical operations to calculate expenses, income, and establish budgets. Additionally, STEM facilitates the comprehension and application of percentage concepts in practical situations, such as computing discounts while shopping or estimating percentage increases or decreases in item prices.

The understanding of probability and statistics acquired through the STEM approach enables students to make better decisions in data analysis or event probability estimation, such as in weather forecasting or investment risk assessment. This aligns with Muzana et al. (2021) research highlighting the positive impact of STEM-based learning on numeracy proficiency. By engaging students in hands-on projects and collaborative problem-solving, STEM education enhances students' mathematical competencies. Furthermore, integrating STEM with everyday life contexts helps students relate mathematical concepts to their practical experiences, enhancing the relevance and interest in their learning (Maass et al., 2019).

The improvement of numeracy literacy at the elementary school level has been widely addressed emphasizing the importance of the STEM approach in enhancing students' numeracy literacy (Adem et al., 2024). Purwaningrum et al. (2023) explained that schools require Android-based learning media and learning resources to enhance students' numeracy literacy skills and recommend the design of digital-based learning activities and interactive learning models by teachers, integration of Android-based media in learning resources, enhancement of teachers' competence in designing mathematics materials, and creation of student books to facilitate digital-based mathematics learning activities. Meanwhile, Adem et al. found that SES indicators in PEMANTIK are well-aligned, with a positive correlation between family SES and students' literacy ($r = .41$) and numeracy ($r = .55$) achievements. Along with the increase in SES, achievements also increase, emphasizing the need for interventions to address inequality and support children with low SES in effectively improving their literacy and numeracy achievements. Furthermore, Yuliana et al. (2023) enhance numeracy literacy through mathematics teaching modules, where ethnomathematics-based teaching modules with a realistic mathematics education approach improve valid, practical, and effective mathematical literacy.

These recent studies have made significant contributions in identifying effective strategies for enhancing mathematical understanding in young children, including in curriculum implementation conducted by Sheth and Pathak (2023), which explores how a STEM curriculum empowers students' numeracy skills. By integrating mathematics with real-world contexts and technology, students develop a deeper understanding of numerical concepts and their applications; thus, strengthening the profile of students' numeracy literacy through STEM is an appropriate choice of effort. As mentioned by Linh et al. (2023) study emphasizes the effectiveness of STEM education in enhancing numeracy literacy among students. Through hands-on activities and real-world applications, students develop a deeper understanding of mathematical concepts and provide an overview of the relationship between STEM education and numeracy literacy (Miller & Krajcik, 2019). The review highlights the importance of integrating mathematics with STEM disciplines to enhance students' numeracy skills.

In the context of STEM education and numeracy literacy in Islamic schools in Thailand, there are several specific aspects that have not been adequately explored. First, the pedagogical approaches that integrate Islamic values with STEM principles and numeracy literacy remain under-researched. The cultural and religious contexts of Islamic schools necessitate a more contextual integration of religious teachings and scientific concepts to ensure that learning is relevant to the student's everyday lives. Second, insufficient attention has been given to developing curricula that balance 21st-century competencies, such as problem-solving and critical thinking, with the spiritual character fostered by Islamic teachings. This has posed a challenge to the optimization of STEM education in these schools.

Additionally, there is a limited exploration of how students in Islamic schools face the challenges of numeracy literacy, particularly in understanding abstract mathematical concepts that may conflict with the rote-based learning methods dominant in traditional Islamic education. Contextual approaches that link numeracy literacy to the realities of Muslim communities, such as sharia-based economics or the use of technology in mosque and zakat management, have also not been widely developed.

Furthermore, the aspect of gender equity in STEM education within Islamic schools requires special attention. In-depth studies on how Islamic schools in Thailand facilitate the participation of female students in STEM and numeracy literacy are still very limited. Despite Islamic values advocating for educational equality, these principles have not been sufficiently leveraged to design more inclusive strategies. Therefore, exploring these aspects contextually would not only enrich research on STEM education and numeracy literacy but also contribute to the development of a more holistic and relevant education system in Islamic schools in Thailand.

Methodology

Research Design

This study adopts a quantitative approach, specifically utilizing a quasi-experimental research design. This design involves the use of two distinct groups: a control group and an experimental group. The experimental group is exposed to the STEM learning intervention, while the control group continues with the standard or traditional teaching methods. The primary goal of this design is to compare the effectiveness of STEM-based learning in improving students' numeracy literacy between the two groups.

Sample and Data Collection

The research sample consists of students from 2 classes at the C-phase level in Eakkapapsasanawich Islamic School, Thailand. The sampling process was conducted randomly to ensure population representativeness. Data were collected through pre-tests to assess students' initial numeracy literacy levels before STEM intervention, and post-tests after the intervention. Additionally, data were obtained through classroom observations, teacher interviews, and student questionnaires to obtain a comprehensive understanding of the learning process.

To ensure the accuracy and dependability of the numeracy literacy tests used in this study, validity, and reliability were carefully assessed and established as follows:

Validity

The validity of the numeracy literacy test was evaluated to ensure it effectively measures what it is intended to measure the students' numeracy literacy skills. The following steps were taken to confirm validity:

Content Validity

Subject matter experts, including STEM education specialists and experienced mathematics teachers, reviewed the test items to confirm alignment with the curriculum objectives and the numeracy literacy competencies outlined for C-phase students in Thailand. Each test item was analyzed for relevance, clarity, and appropriateness.

Construct Validity

The test items were designed to reflect key constructs of numeracy literacy, including number sense, problem-solving, reasoning, and real-world application of mathematical concepts. Statistical analysis was conducted using exploratory factor analysis (EFA) to ensure that the items represented a unified construct of numeracy literacy.

Criterion-related Validity

Pre-test and post-test scores were correlated with students' previous academic performance in mathematics to assess the predictive and concurrent validity of the test.

Reliability

The reliability of the numeracy literacy test was assessed to ensure consistency and stability of the test results across different administrations. The following methods were applied:

Internal Consistency

The reliability of the test was measured using Cronbach's alpha. A coefficient of 0.7 or higher was considered acceptable, indicating that the test items were consistently measuring the same construct.

Test-retest Reliability

A pilot study was conducted in which the test was administered to a group of students with similar characteristics as the research sample on two different occasions. The consistency of the scores across these two administrations was measured to confirm stability over time.

Inter-rater Reliability

For open-ended items requiring qualitative responses, multiple raters scored the responses. The inter-rater reliability was calculated using Cohen's kappa to ensure scoring consistency among the raters.

Implementation in Data Collection

The Stage of Implementing STEM

The stages of implementing STEM (Science, Technology, Engineering, and Mathematics) involve several steps designed to assist students in understanding scientific and mathematical concepts. Here are the stages applied in STEM learning for the subject.

Table 1. Stage Applied in STEM Learning

No	STEM Stage	Subject	Teacher's Activities	Student's Activities	Subject Matter and Activities
1	Understanding Concepts and Objectives	Basic Mathematical Operations	Explaining the basic concepts of basic mathematical operations such as addition, subtraction, multiplication, and division.	Practicing basic mathematical operations by solving various daily problems, such as calculating shopping expenses or daily expenditures.	Students practice basic mathematical operations (addition, subtraction, multiplication, division) in real-life situations such as calculating total expenses at the supermarket.
2	Identification of Literacy and Numeracy Skills	Percentage	Discussing the concept of percentage and its applications in daily life, such as discounts, taxes, and profits.	Applying the concept of percentage in real-life situations, such as calculating discounts while shopping.	Students use the concept of percentage to calculate discounts while shopping, such as calculating the price after a 20% discount.

Table 1. Continued

No	STEM Stage	Subject	Teacher's Activities	Student's Activities	Subject Matter and Activities
3	Problem-Based Activity Planning	Probability	Guiding students in planning and conducting experiments to collect data.	Conducting experiments and collecting data to understand the concept of probability.	Students conduct experiments by rolling dice and collecting data on the outcomes to understand the concept of probability.
4	Collaboration and Exploration	Statistics	Introducing descriptive statistical methods such as mean, median, and mode.	Analyzing experiment results and making predictions based on the data obtained.	Students analyze the results of dice-rolling experiments and make predictions about the likelihood of the next roll based on the data they collected.
5	Problem Solving and Solution Design	Application of Concepts	Assisting students in designing creative solutions to given problems using the learned mathematical concepts.	Conducting surveys or experiments to collect data.	Students conduct a survey in school to gather data on the most popular hobbies among students, then they process the data using descriptive statistical methods.
6	Evaluation and Reflection	Application in Real-World Context	Conducting formative and summative evaluations of student progress. Guiding students to reflect on their learning and identify the application of concepts in real-life situations.	Using descriptive statistical methods to analyze the collected data	The students use descriptive statistical methods (such as mean, median, and mode) to analyze their survey data on students' hobbies in the school.
				Designing solutions to real-world problems involving the application of mathematical concepts. - Testing their solutions and making adjustments if necessary.	The students design solutions to calculate travel time between two cities using mathematical concepts (speed, distance) and test their solutions by comparing the results with the actual time.
				They reflect on their learning and identify how the concepts they have learned can be applied in real-life situations.	Students reflect on their learning from using mathematical concepts in everyday life, such as how they can calculate percentage discounts while shopping.

The implementation of STEM as an effort to strengthen students' literacy and numeracy profiles in basic mathematical operations, percentages, probability, statistics, and their applications has proven to have a significant positive impact, reflected in the improvement of scores from pretest to posttest. Through this approach, students are not only encouraged to understand mathematical concepts theoretically but also to apply them in real-world contexts, enhancing their overall understanding. The implementation of STEM in basic mathematical operations allows students to practice basic mathematical operations by solving various everyday problems, such as calculating expenses or daily expenditures. Thus, they not only learn concepts theoretically but also apply them in real-life situations, which helps reinforce their understanding.

Furthermore, in the topic of percentages, students are given the opportunity to apply percentage concepts in real-world situations, such as calculating discounts while shopping or determining the percentage increase or decrease in prices. Through these activities, students not only understand percentage concepts abstractly but also see their direct relevance in daily life. Then, in the topic of probability, students conduct experiments and collect data to understand probability concepts. They also analyze the results of experiments and make predictions based on the data obtained. Thus, they not only understand probability concepts theoretically but also experience firsthand how these concepts are applied in practice.

In the topic of statistics, students conduct surveys or experiments to collect data, then use descriptive statistical methods to analyze the collected data. Through these activities, students not only understand statistical concepts theoretically but also develop skills in collecting, presenting, and analyzing data. In the problem-solving and solution design stage, students design solutions to real-world problems involving the application of mathematical concepts. They also test their solutions and make adjustments as needed. Thus, students not only understand mathematical concepts theoretically but also develop the ability to apply them in relevant contexts. Through a series of structured and contextually relevant activities, the implementation of STEM has helped students gain a deeper understanding of literacy and numeracy. Therefore, the improvement in scores from pretest to posttest not only reflects an increase in students' understanding of mathematical concepts but also their ability to apply these concepts in everyday life.

During the STEM implementation process, students' responses vary in terms of learning preferences and their level of understanding of the material. Regarding students' responses to the STEM stages, the ones that facilitated their understanding of the material the most and the problems they liked the most varied.

Table 2. The STEM Stage for Facilitating Students in Understanding Subject Matter

The STEM Stage that Most Facilitates Students' Understanding of the Material	**The Most Preferred Question by Students**	**Student Activities**
Practicing Concepts in Real-Life Situations Students feel that this stage is the most helpful for them to understand the material because they can relate the concepts they learn to real-life situations in their daily lives. For example, on the topic of percentages, students find it easier to understand the concept of discounts when shopping or percentage increases in prices because of its relevance to their own experiences.	Problem-Based Questions Students tend to prefer problem-based questions because they challenge students to apply the concepts they have learned in concrete and relevant contexts. For example, on the topic of statistics, students enjoy questions that ask them to analyze data from surveys or experiments they conduct themselves. Question 1: A school wants to know students' interests in sports among soccer, basketball, and badminton. They surveyed 100 students in the school. The survey results show that 40 students like soccer, 30 students like basketball, and the rest like badminton. a) What percentage of students like soccer out of the total number of students surveyed? b) What percentage of students like basketball out of the total number of students surveyed? c) Which sport is the most favored by students based on this survey?	**Problem Solution 1:** Percentage = $\left(\frac{\text{Total number of students}}{\textit{Number of students who like soccer}}\right) \times 100\%$ Percentage = $\frac{40}{100} \times 100\% = 40\%$ **Problem Solution 2:** Percentage = $\left(\frac{\text{Number of students who like basketball}}{\text{Total number of students}}\right) \times 100\%$ Percentage = $\frac{30}{100} \times 100\% = 30\%$ **Problem Solution 3:** Sum up all the time spent by students in completing math homework. 25+30+40+35+20+45+50+55+30+40+35+40+ 25+30+35+40+45+50+55+60=750 Then, we divide the total time by the number of students to get the average. Mean = $\left(\frac{750}{20}\right) = 37.5$ So, the average time spent by students in completing math homework every night is 37.5 minutes.

Based on the implementation of the STEM approach, an improvement in students' literacy and numeracy learning can be observed. This can be illustrated through three examples of student problem-solving tasks provided earlier.

Pre-test

The pre-test, administered before the STEM intervention, was used to assess baseline numeracy literacy levels. This established a point of comparison for evaluating the impact of the intervention.

Post-test

The post-test, administered after the STEM intervention, was used to measure any improvements or changes in students' numeracy literacy skills. The same procedures for validity and reliability were applied to ensure consistent data quality.

Triangulation with Additional Data Sources

To strengthen the validity and reliability of the overall findings, data collected from numeracy literacy tests were triangulated with information from classroom observations, teacher interviews, and student questionnaires. This comprehensive approach provided a deeper understanding of the context and supported the interpretation of test results.

Analyzing of Data

Data analysis was conducted using descriptive and inferential statistical methods, incorporating ANCOVA to account for initial differences in students' numeracy literacy levels. Pre-tests were used as covariates to control for baseline disparities, while post-test scores served as the dependent variable to measure the impact of the STEM intervention. The ANCOVA was applied to evaluate the effectiveness of the STEM approach by comparing the adjusted mean scores of the experimental and control groups, ensuring that the analysis accounted for any pre-existing differences and provided a more precise assessment of the intervention's effectiveness.

Assumption Checks

Table 3. Test for Equality of Variances (Levene's)

F	$df1$	$df2$	p
0.764	1.000	58.000	0.386

The results of Levene's Test for Equality of Variances indicate that the assumption of homogeneity of variances is met. The test yielded an F-value of 0.764 with degrees of freedom (df1 = 1, df2 = 58) and a p-value of 0.386. Since the p-value is greater than the significance level of 0.05, we fail to reject the null hypothesis, suggesting that there is no significant difference in the variances across the groups being compared. This confirms that the variances are equal, satisfying one of the key assumptions for conducting ANCOVA.

Q-Q Plot

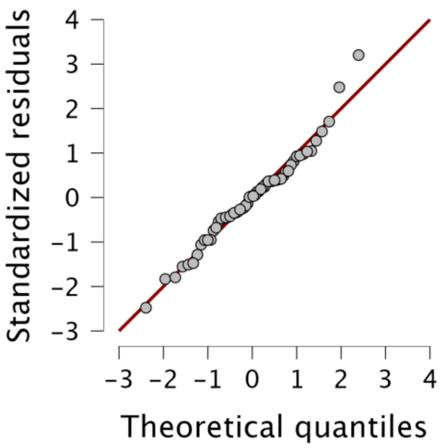


Figure 1. Experimental and Control Class Pre-Test Statistics

The Q-Q plot of the standardized residuals shows that most of the data points align closely with the diagonal reference line, indicating that the residuals are approximately normally distributed. This suggests that the assumption of normality for the residuals in the ANCOVA analysis is satisfied. While there may be slight deviations at the extremes, they appear minimal and are unlikely to significantly affect the validity of the results.

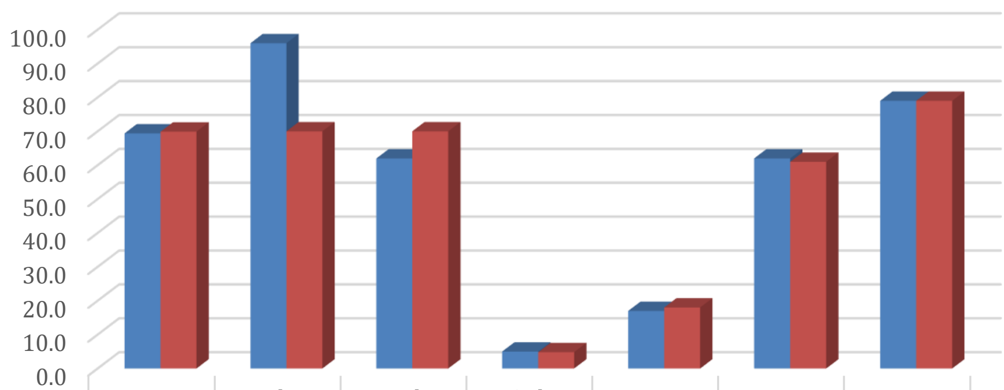
Results

The initial research activity commenced with conducting a pre-test on all students in the C-phase elementary school classes at Eakkapapsasanawich Islamic School, Thailand, regarding the students' initial numeracy literacy levels before STEM intervention. The pre-test results from these two classes are presented in Table 4 as follows.

Table 4. Preliminary Test Results

Interval Score	Category	Experimental		Control	
		Frequency	Percentage	Frequency	Percentage
0 – 39	Very Low	0	0	0	0
40 – 59	Low	0	0	0	0
60 – 74	Medium	24	80	23	77
75 – 90	High	6	20	7	23
91 – 100	Very High	0	0	0	0
	Sum	30	100	30	100

Before commencing the analysis of intervention effectiveness, it is important to gain an initial understanding of the baseline characteristics of the two compared groups. Descriptive statistics, on the pre-tests of the experimental and control groups, provide a comprehensive overview of the distribution of test scores before the implementation of the STEM approach. By analyzing the mean, median, mode, and measures of spread such as standard deviation, the level of initial understanding and variation in literacy and numeracy abilities between the two groups are obtained and presented in the following graph.



	Mean	Median	Mode	Std. Deviation	Range	Minimum	Maximum
Statistics Experimental	69.4	96.0	62.0	5.0	17.0	62.0	79.0
Statistics Control	69.9	70.0	70.0	4.8	18.0	61.0	79.0

Figure 2. Experimental and Control Class Pre-Test Statistics

In the comparative analysis of descriptive statistics between the experimental and control groups, significant differences are observed in several key parameters. Overall, the average test score in the experimental group is 69.4, whereas the control group records a slightly higher average of 69.9. However, when examining the median, the middle value in both groups shows a considerable difference, with the median score in the experimental group being 96.0 and the control group being 70.0. Additionally, the mode, representing the most frequently occurring value in the dataset, indicates a significant difference between the experimental group (62.0) and the control group (70.0). However, the standard deviation, which measures the spread of data relative to the mean, shows a relatively insignificant difference, with the experimental group having a standard deviation of 5.0 and the control group having a standard deviation of 4.8. The range of values, which is the difference between the maximum and minimum values, also shows a slight difference, with the experimental group having a range of 17.0 while the control group has a range of 18.0.

Following the initial testing, the final assessment of students' literacy and numeracy skills through STEM is conducted, as presented in the following table.

Table 5. The Final Test Results

Interval Score	Category	Experimental		Control	
		Frequency	Percentage	Frequency	Percentage
0 – 39	Very Low	0	0	0	0
40 – 59	Low	0	0	0	0
60 – 74	Medium	0	0	8	27
75 – 90	High	30	100	22	73
91 – 100	Very High	0	0	0	0
	Sum	30	100	30	100

The analysis of the final results of the experimental and control groups at the level of achievement categories reveals a significant difference. The majority of students in the control group are in the medium category, accounting for 27% of the proportion. The high category shows a clear improvement in achievement after treatment, with 100% of students from the experimental class and 73% of students from the control class reaching this level. However, the categories of very low, low, and very high are not represented in both groups, indicating that no students reached the lowest or highest levels of achievement in the post-test. Thus, this data distribution provides a strong indication of the difference in achievement between the two groups after the intervention, with the most significant improvement observed in the high category in both groups. Furthermore, the statistical analysis of the averages of both groups is presented in the following graph.

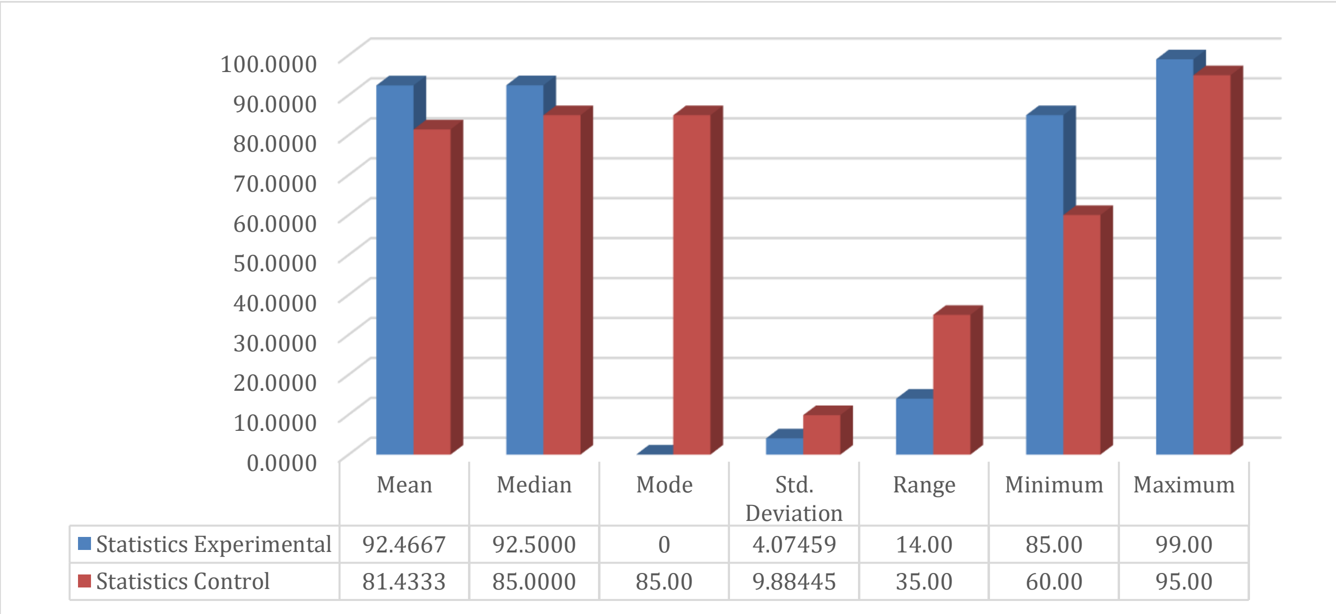


Figure 3. Experimental and Control Class Pre-Test Statistics

Overall, the average test score in the experimental group is 92.47, which is significantly higher compared to the average of the control group, which only reaches 81.43. However, when looking at the median, the middle values in both groups are relatively close, with the median value in the experimental class being 92.50 and in the control class being 85.00. However, there is a significant difference in the mode, which represents the most frequently occurring value in the dataset. The mode in the experimental group is 90.00, while in the control group, it is 85.00. The standard deviation, which measures the relative to the mean, shows a significant difference between the two groups, with a value of 4.07 for the experimental group and 9.88 for the control group. The range of values, which is the difference between the maximum and minimum values, also shows a significant difference, with the experimental group having a range of 14.00 while the control group has a range of 35.00. This indicates a greater variation in the distribution of test scores in the control group. Thus, although there are some similarities in median values, significant differences are observed in the mean, mode, standard deviation, and range between the two groups, indicating the different impacts of the intervention or treatment given to the students. Next, to test the effectiveness of implementing the STEM approach between the experimental and control groups, the testing proceeded with an ANCOVA.

Table 6. The Results of the ANCOVA Analysis

ANCOVA - Post

Cases	Sum of Squares	df	Mean Square	*F*	*p*	ω^2
Model	57.502	1	57.502	10.388	0.002	0.032
Pre	1237.637	1	1237.637	223.581	< .001	0.762
Residuals	315.525	57	5.536			

Note. Type III Sum of Squares

The results of the ANCOVA analysis indicate that the overall model has a significant contribution in explaining the differences in post-test scores after controlling for pre-test scores ($F = 10.388, p = .002, \omega^2 = .032$). This suggests that the independent variables included in the model have a significant effect on the post-test scores.

The pre-test scores also make a highly significant contribution to the post-test scores, with $F = 223.581$ and $p < .001$, indicating that the pre-test scores are a strong covariate in this model. The ω^2 value of 0.762 demonstrates that the pre-test scores account for a substantial portion of the variability in post-test scores, highlighting the importance of controlling for this variable in the analysis.

The residuals have a Mean Square value of 5.536, indicating the remaining variability after accounting for the variables included in the model. Overall, these results show that the model used in the ANCOVA analysis is effective in explaining significant differences in post-test scores after accounting for the influence of pre-test scores.

Post Hoc Comparisons - Model

		Mean Difference	SE	t	Cohen's d	p_{tukey}
Without Stem	With Stem	-2.330	0.723	-3.223	-0.990	0.002

The post hoc test results using the Least Significant Difference (LSD) method indicate a significant difference between the groups "Without STEM" and "With STEM." The mean difference is -2.330, with a standard error (SE) of 0.723, resulting in a t-value of -3.223 and a p-value of 0.002. This p-value is below the threshold of 0.05, indicating that the difference in mean scores between the two groups is statistically significant.

The effect size, represented by Cohen's d, is -0.990, suggesting a medium to large effect size. This indicates that the implementation of the STEM approach has a substantial impact on the outcomes compared to the group without STEM. These findings support the effectiveness of the STEM approach in improving performance or outcomes in this context.

Discussion

The results of the ANCOVA analysis indicate that the overall model is significant in explaining the differences in post-test scores after controlling for the covariate, namely the pre-test scores ($F = 10.388, p = .002$). The STEM approach to learning has been proven to have a significant impact on student learning outcomes, although its contribution to the total variability in post-test scores is relatively small ($\omega^2 = .032$). Meanwhile, the pre-test scores as a covariate have a very significant influence on the post-test scores ($F = 223.581, p < .001, \omega^2 = .762$), indicating that initial differences among students are a key factor that must be controlled to provide a more accurate estimate of the effectiveness of the learning approach. The residuals indicate remaining variability (Mean Square = 5.536), suggesting that there are still other factors not accounted for in the model. Overall, this analysis validates that the STEM approach is effective in improving student learning outcomes and demonstrates its potential for broader implementation, with the critical note of addressing initial disparities among students to maximize the impact of the learning approach.

Improvement in Understanding Mathematical Concepts

In the first example of a problem regarding students' interest in sports, students had to use the concept of percentages to calculate the number of students who liked each sport and determine the most favored sport. This process allowed students to apply their understanding of percentages in a context relevant to everyday life, such as a survey on sports interests. Thus, the implementation of STEM enabled students to comprehend and internalize mathematical concepts more effectively.

Application of Statistical Concepts in Real-World Contexts

In the second example problem about the time spent by students completing math homework, students had to use statistical concepts such as mean and median to analyze data. By involving students in the collection and analysis of data relevant to their everyday experiences, the implementation of STEM allows students to develop a deeper understanding of statistical concepts and how to use them in real-world situations.

Improvement in Problem-Solving Skills

In both example problems, students were presented with problems that required problem-solving and the application of mathematical concepts in concrete and relevant contexts. By facing such problems, students are encouraged to think critically, develop problem-solving strategies, and apply the mathematical concepts they have learned. This process not only helps students understand the material but also enhances their problem-solving skills in general.

Thus, the implementation of STEM not only enhances students' understanding of mathematical concepts but also helps them develop critical skills and apply these concepts in real-world contexts. This significantly contributes to overall student numeracy literacy.

The reinforcement of students' numeracy literacy profile through STEM is also evidenced by the analysis of the "Independent Samples Test," where the Sig. value (2-tailed) is found to be 0.000 < 0.05. Therefore, based on the decision-making basis in the independent sample t-test, it can be concluded that there is a significant difference between the mean learning outcomes of students in the experimental group and the control group where STEM approach is effective in enhancing the literacy and numeracy learning profile of students. The results of the initial test before the implementation of STEM showed that students in the experimental class were mainly in the medium category, with 80%, whereas after the treatment, students overall in the experimental class were in the high category.

These findings are consistent with research on the implementation of STEM in literacy and numeracy education, which reveals various significant findings across different educational levels. For instance, a study by Linh et al. (2023) evaluated the effects of STEM education on mathematics achievement among high school students, showing a significant improvement in numeracy skills following the implementation of a STEM-based curriculum. Another study by Baek et al. (2023) explored the integration of STEM in early childhood education, finding that this approach could enhance reading interest and basic literacy skills in young children.

Muzana et al. (2021) discussed the contribution of STEM education to the development of critical thinking and numeracy skills among elementary school students, with results indicating improved analytical and problem-solving abilities. Additionally, research by Liu et al. (2020) demonstrated the effectiveness of STEM programs in enhancing literacy skills among middle school students, particularly in reading comprehension and writing abilities.

In the context of underprivileged communities, Kelley and Knowles (2016) highlighted the role of STEM in addressing numeracy gaps, showing that this approach can improve numeracy skills and open up further educational opportunities. Meanwhile, Drake and Reid (2018) examined the integration of STEM and literacy as a multidisciplinary approach, which was found to enhance communication skills and understanding of scientific concepts among students.

Another study by Movahedazarhouligh et al. (2023) evaluated STEM as a catalyst for improving numeracy skills in high school students, revealing that this approach could increase both interest and achievement in mathematics. At the elementary level, Clements and Sarama (2016) found that STEM-based learning significantly supports literacy development, including reading and writing skills, through interactive activities.

Moreover, English (2023), in a case study, highlighted the effectiveness of STEM education in addressing students' numeracy deficiencies, both in basic and advanced numeracy skills. Finally, Yuliardi and Dahlan (2023) evaluated integrated STEM curricula, finding that this approach could enhance understanding and practical application of literacy and numeracy concepts.

In line with Linh et al. (2023), the study emphasizes the effectiveness of STEM education in enhancing numeracy literacy among students. Through hands-on activities and real-world applications, students develop a deeper understanding of mathematical concepts. Similarly, Baek et al. (2023) discuss how STEM education promotes numeracy literacy by integrating mathematics with science, technology, and engineering. This interdisciplinary approach fosters critical thinking and problem-solving skills essential for numeracy.

In the context of literacy, the findings from Eakkapapsasanawich align with Drake and Reid (2018) study, which stated that the integration of STEM with a multidisciplinary approach can enhance communication skills and understanding of scientific concepts. Furthermore, these findings are consistent with English's (2023) research, which demonstrated that STEM can effectively address students' numeracy deficiencies.

However, the findings at Eakkapapsasanawich exhibit uniqueness in their application within the context of an Islamic school. The STEM approach is integrated with local values and the specific needs of the Muslim community, making it relevant to the culture and needs of the students. This adds a broader perspective, showing that STEM is not only effective in improving numeracy literacy but also flexible enough to be adapted to various educational contexts that incorporate religious values.

These findings consistently demonstrate that the STEM approach has a significant positive impact on improving literacy and numeracy, both individually and as part of a multidisciplinary strategy to support skill development among students across various educational levels.

Conclusion

This approach enables students to achieve a profound understanding of scientific and mathematical concepts while simultaneously fostering critical thinking, problem-solving, and collaboration skills. By engaging students in a comprehensive learning process—spanning problem identification, research, solution planning, implementation, evaluation, and reflection—STEM facilitates the practical application of concepts in real-life contexts. Consequently, the STEM approach serves as a robust foundation for enhancing numeracy literacy and equipping students with essential 21st-century skills.

Recommendations

Schools can integrate the STEM approach into the curriculum comprehensively to enhance students' numeracy literacy. This involves developing learning units that combine concepts of science, technology, engineering, and mathematics in meaningful and relevant contexts. With this approach, students can experience how numeracy concepts are applied in real-world situations, deepen their understanding of the material, and develop critical thinking and problem-solving skills.

Schools can provide adequate training for teachers to develop skills and knowledge in STEM teaching. This training may include introducing the STEM learning approach, using technology and STEM tools in teaching, and strategies for integrating STEM concepts into the existing curriculum. By strengthening teachers' competencies in STEM teaching, schools can ensure that students gain valuable and effective learning experiences that strengthen their numeracy literacy.

Limitations

Some limitations of the findings on strengthening students' numeracy literacy profile through STEM at Eakkapapsasanawich Islamic School Thailand are (1) the findings may have limitations in generalization because they are based on the specific context of that school. Unique factors such as school policies, school culture, and student backgrounds can influence the findings and may not fully reflect experiences in other schools. (2) the findings reflect the results of specific timing and implementation. Changes in school policies, curriculum structures, or other evolving factors over time may have different impacts on the effectiveness of the STEM approach in strengthening students' numeracy literacy. (3) Another limitation arises from individual variations among students. The STEM approach may be more effective for some students than others, depending on their learning styles, interests, or numeracy skill levels.

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Conflict of Interest

The authors declare that there is no conflict of interest.

Authorship Contribution Statement

Agustan Syamsuddin: Concept and design, data acquisition, data analysis / interpretation, drafting manuscript, critical revision of manuscript, design, collecting data, analyzing data, statistical analysis, editing/reviewing and writing. Reangchai Pungen: Reviewing, supervision, collecting data, analyzing data. Sri Satriani: Reviewing, supervision, collecting data, analyzing data, critical revision of manuscript, statistical analysis. Nusyaida: Admin, technical or material support, supervision, collecting data. Rahmawati: Data analysis / interpretation, drafting manuscript, critical revision of manuscript.

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