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Scientific-Based Numeracy Literacy Teaching Materials in Learning Management: Student Motivation and Higher Thinking Skills

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ABSTRACT

Purpose – This study aims to analyze the effect of science-based numeracy literacy teaching materials in learning management on students' motivation and higher-order thinking skills.

Methodology—This study uses a quantitative approach with a quasi-experimental method that applies a nonequivalent control group design. The sample was selected using a purposive sampling technique so that the subjects met specific criteria set out by the study's objectives. The instruments used in data collection include questionnaires to measure motivation and tests designed to assess high-order thinking skills. The data obtained were analyzed using an independent sample t-test, which aims to see significant differences between the experimental and control groups in the variables studied.

Findings – The results showed a difference in the average score of the experimental class post-test motivation of 80.77, while the control group post-test was 70.77, while the average score of higher order thinking skills of the experimental class post-test was 80.36, while the control group post-test was 65.06. Sig (2-tailed) independent sample t-test value of motivation and higher-order thinking skills is 0.000 <0.05. This shows a significant difference (real) between experimental and control group students' motivation scores and higher-order thinking skills using scientific-based numeracy literacy teaching materials in learning management.

Significance – This research contributes significantly to developing scientific-based numeracy literacy teaching materials in higher education, especially in improving the quality of learning and interaction between lecturers and students.

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INTRODUCTION

The scientific approach is an important skill that students need to have. With this skill, students can apply the knowledge they have learned, deepen their understanding of concepts, and develop creativity and communication skills. The scientific approach also helps students solve various problems in everyday life (Eek & Stigmar, 2024; Kanphukiew & Nuangchalerm, 2024). In addition, the scientific approach plays an important role in everyday life, especially in the 21st century. Individuals need scientific knowledge and a good understanding of the latest technological developments. This is important so they can adapt and face the challenges that arise along with the times (Kholifah et al., 2023; Kholili et al., 2024; Dašić et al., 2024).

In facing the challenges of the 21st century, education is required to not only develop students' cognitive aspects in the form of mastery of subject matter but also foster higher-order thinking skills and strong learning motivation (Afikah et al., 2023; Mutohhari et al., 2021). One of the crucial aspects in this regard is numeracy literacy, which is the ability to understand, use, and analyze quantitative information in various life contexts. Unfortunately, the results of educational evaluations such as PISA still show that the numeracy skills of students in Indonesia have not achieved satisfactory results. This condition shows the need for innovation in developing teaching materials to bridge numeracy concepts with relevant and applicable learning approaches (Andari & Setianingsih, 2021; Hidayah et al., 2025).

One of the causes of low numeracy skills is the use of teaching materials that are not contextualized and do not stimulate students' higher-order thinking (Pramasdyahsari et al., 2023). Many available teaching materials are conventional, oriented towards memorizing formulas and mechanical procedures, and do not relate numeracy material to the context of students' real lives. This makes it difficult for students to understand concepts deeply, and they are not used to developing higher-order thinking skills such as analyzing, evaluating, and synthesizing information. In meaningful learning, students should be allowed to explore and construct knowledge through active, creative, and contextual learning experiences (Habsah, 2017; Rejekiningsih et al., 2023). Therefore, it is necessary to develop teaching materials that integrate the scientific approach into the learning process. Thus, scientific-based numeracy literacy teaching materials are expected to be a strategic solution in answering these challenges.

The developed scientific-based numeracy literacy teaching materials have significant advantages in improving the quality of learning and developing students' numeracy skills. One of the advantages is its ability to encourage students to think critically and analytically through an approach that involves scientific processes. Using stages such as observing, questioning, trying, reasoning, and communicating, this teaching material theoretically teaches numeracy concepts and invites students to actively engage in discovery and problem-solving. This strengthens students' understanding of the material and helps them relate mathematical concepts to real-life situations (Ramdani et al., 2021). The scientific-based numeracy literacy teaching materials also emphasize the importance of data- and evidence-based learning. Students are trained to collect, analyze, and interpret numerical information, which enriches their ability to make rational decisions. Thus, these teaching materials focus on achieving technical skills in numeracy and developing the thinking skills needed to solve complex problems, such as those often encountered in the real world (Rangkuti et al., 2024).

Some previous studies have highlighted numeracy literacy's role in improving students' cognitive abilities. However, few still examine integrating science-based teaching materials in learning management to increase students' learning motivation and higher-order thinking skills simultaneously. Theoretically, numeracy literacy has been associated with improved cognitive skills, especially in analyzing, evaluating, and synthesizing quantitative information. However, few studies have integrated science-based teaching materials in learning management to measure their impact on students' motivation and higher-order thinking skills. Practically, using science-based numeracy literacy teaching materials in learning management is still not the main approach in learning design in many higher education institutions. Lecturers use conventional teaching materials that do not fully accommodate strategies to improve students' numeracy, literacy, and critical thinking. This concept is in line with Niels Jahnke & Hefendehl-Hebeker's (2016) research that revealed the importance of numeracy literacy in the context of mathematics education but did not discuss how numeracy literacy is integrated into learning management or the role of motivation in student learning success. This suggests a gap in research linking cognitive and motivational aspects in applying science-based numeracy literacy. Lin et al. (2023) also revealed the relationship between teaching critical thinking and student motivation. However, this study mainly examines motivation in a general context and has not specifically discussed the application of motivation in the context of science-based numeracy literacy, especially in a higher education environment. Therefore, this study becomes relevant to fill the existing gap by providing empirical evidence regarding the effectiveness of science-based numeracy literacy teaching materials in learning management on students' motivation and higher-order thinking skills.

The novelty of this research lies in the integrative approach that places teaching materials not only as a medium for conveying information but also as a strategic instrument in learning management designed to stimulate students' intrinsic motivation and cognitive engagement. Through a scientific approach emphasizing observing, questioning, trying, reasoning, and communicating, teaching materials are developed to improve the understanding of numeracy concepts and activate students' critical, analytical, and reflective thinking processes. In addition, the novelty of this research also lies in the perspective of learning management as a dynamic system that can be modified through strengthening teaching materials. Thus, this research provides theoretical and practical contributions to developing learning designs that are more contextual, adaptive, and oriented toward simultaneously developing students' cognitive and affective potential. Thus, this study aims to analyze the effect of scientific-based numeracy literacy teaching materials in learning management on students' motivation and higher-order thinking skills.

METHODOLOGY

Research Design

The research method used in this study is quantitative and quasi-experimental (Campbell & Stanley, 1963). This approach was chosen because it allows researchers to test the effect of specific treatments on the dependent variable, even though there is no randomization of the research subjects. The design used was a nonequivalent control group design with a pretest-posttest pattern. In this design, two groups are not randomly selected: the experimental and the control groups. Both groups were given an initial test (pretest), but only the experimental group received treatment through scientific numeracy literacy-based teaching materials. After the treatment, both groups were given a final test (post-test) to see the improvement in learning outcomes and motivation. This design is designed to see how much influence scientific-based teaching materials have on improving higher-order thinking skills (HOTS) and student learning motivation compared to conventional learning. This design is suitable for use in real learning situations in higher education, especially when the division of classes cannot be done randomly.

Participant

The population in this study were all seventh-semester students of the Elementary School Teacher Education Study Programme (PGSD) at Quality Medan University who attended the Elementary School Learning Strategy course, totaling 295 students. From this population, the researcher took a sample of 64 students, which were divided into two classes: The experimental group of 32 students and the Control group of 32 students. The sampling technique used purposive sampling, considering several criteria, namely, students who take the appropriate courses, are willing to participate in the entire learning process during the study and are supported by lecturers willing to apply the scientific approach. The use of this purposive technique is based on consideration of the effectiveness of the implementation of treatment by the research objectives. This sample size reference refers to Cohen (1988) in the minimal power analysis for quasi-experimental designs.

Research Instrument and Data Collection

High-Level Thinking Skills (HOTS) Test

This test was prepared to describe 10 questions referring to Bloom's revised taxonomy's three levels: analyzing, evaluating, and creating. A team of basic education experts tested the test's content validity, while empirical validity shows that all items have a correlation coefficient of more than 0.30. The test also had high reliability, with a Cronbach's Alpha value of 0.82, indicating good internal consistency.

Learning Motivation Questionnaire

This questionnaire comprises 25 statement items on a 1-5 Likert scale. It was developed based on John Keller's ARCS (Attention, Relevance, Confidence, Satisfaction) model. The construct validity test showed a KMO value of 0.787, which is suitable for factor analysis. This questionnaire also has high reliability, with a Cronbach's Alpha value of 0.88.

Student Activity Observation Sheet

Observations were made during the learning process, covering student activeness, participation, independence, and collaboration. Scores were given in the range of 1 to 4 and were filled in by pre-trained observers.

Documentation

Documentation was used as supporting data, such as photos of learning activities, student work, lecturer notes, and learning video recordings.

Research Procedure

This study was conducted for 4 weeks with a total of 8 meetings. The treatment stages in each group are as follows:

Experiment Group

Students in this group were given learning using scientific numeracy literacy-based teaching materials. Teaching materials are prepared with a scientific approach, which includes five steps: observing, questioning, trying, reasoning, and communicating (5M). Learning activities are supported by contextualized Learner Worksheets (LKPD) and other interactive materials. This approach emphasizes students' active involvement in building understanding through explorative and reflective activities.

Control Group

Students in this group followed a conventional learning approach, namely the lecture method, simple discussions, and assignments using standard teaching materials. The learning process runs as usual without the intervention of new teaching materials.

Both groups were given a pretest at the beginning and a post-test at the end of the meeting to see if there were differences in learning outcomes and learning motivation after treatment. The research procedure includes planning, implementation, and data analysis. This research design can be seen in Table 1.

Table 1. Research design

Group	Pretest	Treatment	Post-test
Experiment	O_1	X_1	O_2
Control	O_1	X_2	O_2

Treatment in the experimental group in the form of learning using science-based numeracy literacy teaching materials = X1. Treatment in the control group in the form of learning without using scientific-based numeracy literacy teaching materials = X2. Pretest (initial test before treatment) = O1, and Post-test (final test after treatment) = O2.

Data Analysis

Data analysis in this study was conducted quantitatively with two main stages: prerequisite testing and hypothesis testing. Before conducting hypothesis testing, a prerequisite test was carried out to ensure that the data fulfilled the assumptions of parametric statistics. The prerequisite tests used include normality and homogeneity test. The normality test aims to determine whether the data is normally distributed. The test was conducted using the Kolmogorov-Smirnov test on pretest and post-test data for each variable (learning motivation and HOTS) in the experimental and control groups. Data is normally distributed if the significance value (p) > 0.05. The homogeneity test determines whether the variance between groups is homogeneous. Testing is done using Levene's Test. Data is said to be homogeneous if the significance value (p) > 0.05.

After the data met the normality and homogeneity requirements, hypothesis testing was continued using the Independent Sample t-test. This test is used to determine whether there is a significant difference between the experimental group and the control group on two variables, namely learning motivation and HOTS. Decision-making in the t-test is done by comparing the significance value (Sig./p-value) with the significance level (α) of 0.05:

- If p-value < 0.05 → there is a significant difference between the two groups.
- If p-value ≥ 0.05 → there is no significant difference between the two groups.

FINDINGS

Data regarding students' motivation and higher-order thinking skills were obtained from research conducted on Quality University Medan students. The research data is described in detail as follows:

Normality Test of Student Learning Motivation

Table 2. Tests of Normality motivate

		Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Class	Statistic	Df	Sig.	Statistic	Df	Sig.
Result	Pretest Experiment	.100	32	.200*	.972	32	.560
	Post-test Experiment	.093	32	.200*	.965	32	.374
	Pretest Control	.157	32	.045	.955	32	.201
	Post-test Control	.112	32	.200*	.963	32	.341

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

Table 2 shows that the Sig of the experimental group's pretest is 0.560 > 0.05, and the Sig of the experimental group's Post-test is 0.374 > 0.05. In the control group, the Sig of the pretest is 0.201 > 0.05, and the Sig of the Post-test is 0.341 > 0.05. These results indicate that the data normality test in the experimental and control groups of student learning motivation is normally distributed.

Homogeneity Test of Student Learning Motivation

Table 3. Test of Homogeneity of Variance Motivation

		Levene Statistic	df1	df2	Sig.
Result	Based on Mean	.238	1	62	.628
	Based on Median	.238	1	62	.628
	Based on the Median and with adjusted df	.238	1	60.690	.628
	Based on trimmed mean	.237	1	62	.628

Table 3 shows the significance value (Sig.) of student learning motivation is 0.628. Because the value of Sig. 0.628 > 0.05, the variance of student learning motivation data in the experimental and control groups is homogeneous.

Descriptive Test of Student Learning Motivation Statistics

Table 4. Descriptive Statistics Motivation

	N	Minimum	Maximum	Mean	Std. Deviation
Pretest Experiment	32	50	69	59.31	4.730
Posttest Eksperiment	32	75	90	83.77	4.286
Pretest Control	32	52	69	59.62	4.537
Posttest Control	32	62	84	70.77	4.750
Valid N (listwise)	32				

Table 4 and Figure 1 show that the total data for the experimental group is 32 students, and the control group is 32 students. In the control group, there was an increase from the pretest score of 59.62 to 70.77 in the Post-test. This shows an increase in motivation even without special treatment. Meanwhile, the pretest score in the experimental group was 59.31, almost the same as in the control group. However, after the experimental treatment, the post-test score increased significantly to 83.77. The much larger increase in the experimental group compared to the control group shows that the treatment in the experiment contributed effectively to the increase in motivation. This indicates that the intervention or method applied in the experimental group had a more substantial impact on increasing motivation than the control condition.

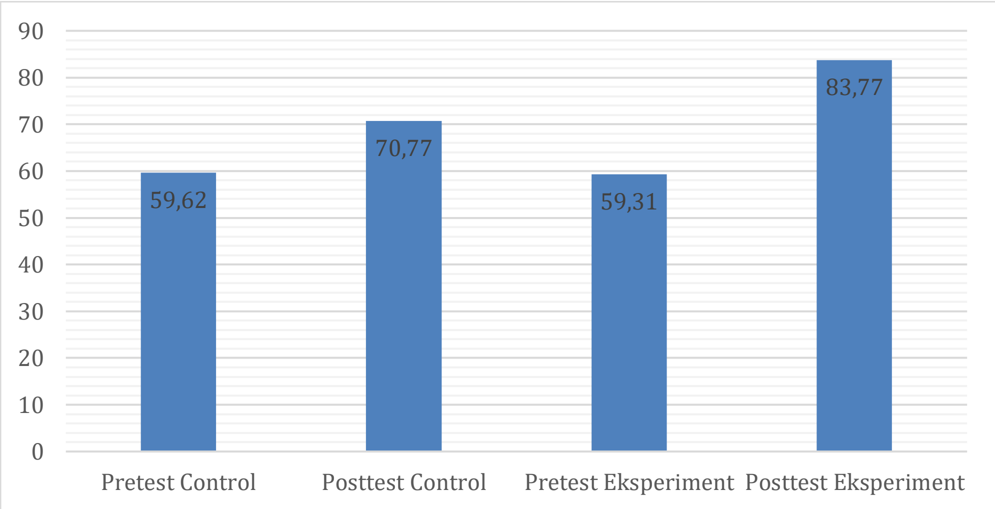

Figure 1. Average Difference in Student Learning Motivation

Practically, this difference indicates that the scientific-based teaching materials provide statistically significant effects and substantially influence educational practice. The much larger increase in scores in the experimental group shows the effectiveness of the intervention in increasing learning motivation in real terms. When viewed from the perspective of practical influence (real effects in the context of learning), these results indicate that scientific-based learning strategies have the potential to be adopted more widely to improve the quality of student engagement and motivation in the learning process.

Hypothesis Test of Student Learning Motivation

Table 5. Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval	
									Lower	Upper
Motivation	Equal variances assumed	.238	.628	11.493	62	.000	12.99844	1.13100	10.73760	15.25928
	Equal variances are not assumed.			11.493	61.358	.000	12.99844	1.13100	10.73713	15.25975

Based on Table 5, the Sig (2-tailed) value is 0.000 <0.05. So, as the basis for decision-making in the independent sample t-test, it can be concluded that Ho is rejected and Ha is accepted. Thus, there is a significant difference (real) between the average student learning motivation in the experimental and control groups using scientific-based numeracy literacy teaching materials in learning management. Furthermore, the 'Mean Difference' value is 13. This value indicates the difference in the average post-test score of the experimental and control groups, or 83.77-70.77 = 13, and the difference is 10.73760 to 15.25928 (95% Confidence Interval of the Difference).

More than being statistically significant, this result also reflects the strong causal contribution of the treatment to the increase in learning motivation. Referring to Keller's (1987) ARCS (Attention, Relevance, Confidence, Satisfaction) theory, scientific-based learning tends to increase attention and relevance through contextual and explorative activities. Students are more interested and feel the learning is relevant to their needs and the real world, increasing their intrinsic motivation. Thus, these findings show numerical differences between groups and demonstrate that the intervention of scientific-based teaching materials theoretically and empirically contributes significantly to increasing student learning motivation. This supports the need for innovation in preparing teaching materials focusing on the content, approach, and delivery strategy.

Normality Test of Students' Higher Order Thinking Ability

Table 6. Tests of Normality Higher order thinking ability

		Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Class	Statistic	df	Sig.	Statistic	df	Sig.
Result	Pretest Experiment	.096	32	.200*	.955	32	.206
	Post-test Experiment	.129	32	.190	.968	32	.455
	Pretest Control	.064	32	.200*	.983	32	.887
	Post-test Control	.119	32	.200*	.975	32	.646

*. This is a lower bound of the true significance.
a. Lilliefors Significance Correction

Table 6 shows that the Sig of the experimental group pretest is 0.206 > 0.05, and the Sig of the experimental group post-test is 0.455 > 0.05. In the control group, the Sig of the pretest is 0.887 > 0.05, and the Sig of the Post-test is 0.646 > 0.05. These results indicate that the data normality test of students' higher-order thinking skills in the experimental and control groups is normally distributed.

Test of Homogeneity of Students' Higher-Order Thinking Ability

Table 7. Test of Homogeneity of Variance Higher Order Thinking Ability

		Levene Statistic	df1	df2	Sig.
Result	Based on Mean	.411	1	62	.524
	Based on Median	.510	1	62	.478
	Based on the Median and with adjusted df	.510	1	60.780	.478
	Based on trimmed mean	.412	1	62	.523

Table 7 shows the significance value (Sig.) of students' higher-order thinking ability is 0.524. Because the value of Sig. 0.524 > 0.05, the variance of students' higher-order thinking ability data in the experimental and control groups is homogeneous.

Statistical Descriptive Test of Students' Higher Order Thinking Ability

Table 8. Descriptive Statistics Higher-order thinking ability

	N	Minimum	Maximum	Mean	Std. Deviation
Pretest Experiment	32	45	66	58.24	4.869
Posttest Eksperiment	32	70	92	80.36	5.062
Pretest Control	32	41	68	56.47	5.817
Posttest Control	32	55	76	65.06	5.122
Valid N (listwise)	32				

Table 8 and Figure 2 show that the total data for the experimental group is 32 students, and the control group is 32 students. In the control group, the pretest score of 56.47 increased to 65.06 in the Post-test. This shows an increase in higher-order thinking skills even without special treatment. Meanwhile, in the experimental group, the pretest score of 58.24, slightly higher than the control group, experienced a much greater increase after treatment, reaching 80.36 in the Post-test.

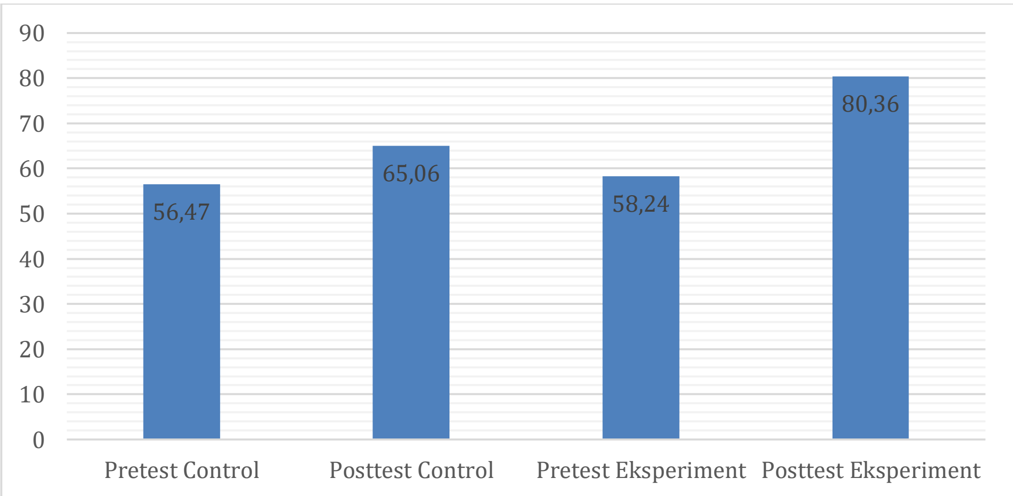

Figure 2. Differences in Students' Higher-Order Thinking Ability

This difference is not only quantitatively significant but also of practical value and instructional significance. The significant increase in HOTS in the experimental group indicates that the scientific-based teaching materials created a challenging and contextualized learning environment, crucial in developing higher-order thinking skills such as analysis, evaluation, and synthesis. In cognitive theory, this finding reinforces Bloom and Anderson's (2001) view that HOTS can be effectively improved through active and constructivist learning strategies. Scientific-based teaching materials require students to engage in data-based exploration, observation, reasoning, and problem-solving processes, which directly train them in higher-order cognitive domains. Practically, this confirms the importance of developing teaching materials that convey information and are designed to stimulate complex mental activities. Thus, it can be concluded that the increase in HOTS in the experimental group was not only statistically different but also practically valuable and pedagogically relevant, indicating that the intervention of scientific-based teaching materials is an effective strategy to improve the quality of learning, especially in terms of developing higher order thinking skills.

Hypothesis Test of Students' Higher-Order Thinking Ability

Table 9. Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval	
									Lower	Upper
Higher Order Thinking	Equal variances assumed	.335	.565	12.024	62	.000	15.30719	1.27300	12.7625	17.8519
	Equal variances are not assumed.			12.024	61.992	.000	15.30719	1.27300	12.7625	17.8519

Based on Table 9, the Sig (2-tailed) value is 0.000 <0.05. So, as the basis for decision-making in the independent sample t-test, it can be concluded that Ho is rejected and Ha is accepted. Thus, there is a significant difference (real) between students' average higher-order thinking skills in the experimental group and the control group using scientific-based numeracy literacy teaching materials in learning management. Furthermore, the 'Mean Difference' value is 15.3. This value shows the difference in the average post-test score of the experimental and control groups, or 80.36-65.06 = 15.3, and the difference is 12.7625 to 17.8519 (95% Confidence Interval of the Difference).

More than just a difference in scores, these results reflect the causal contribution of the treatment given to the experimental group. The treatment using scientific-based teaching materials improves learning outcomes numerically and creates profound cognitive changes supporting higher-order thinking skills. This is consistent with constructivist theory, where students construct knowledge through active and meaningful learning experiences (Vygotsky, 1978). Teaching materials with a scientific approach guide students through observation, data collection, reasoning, and inference, all key components in HOTS. This process strengthens analytical, evaluative, and creative thinking skills. These results show that using scientific-based teaching materials impacts academic achievement in general and explicitly transforms students' thinking, making them better prepared to face the challenges of the 21st century that demand higher-order thinking skills. Thus, this t-test shows both statistical significance and practical and pedagogical significance, strengthening the argument that the intervention in scientific teaching materials needs to be adopted more widely in numeracy literacy-based learning.

DISCUSSION

Based on the results of hypothesis testing using an independent sample t-test displayed in Table 5, it is found that the Sig (2-tailed) value is 0.000, which is smaller than 0.05. This shows a significant difference between the average student learning motivation in the experimental and control groups. This shows a significant difference between the average student learning motivation in the experimental and control groups. In other words, the use of scientific-based numeracy literacy teaching materials in learning management has a significant effect on increasing student learning motivation. The t-test results showed that the experimental group, which used scientific-based numeracy literacy teaching materials, had a higher average learning motivation score than the control group. The 'Mean Difference' value of 12.99844 shows the difference in the average post-test score between the experimental and control groups. With a 95% confidence interval (10.73760 to 15.25928), this result further strengthens the finding that using innovative teaching materials significantly contributes to increasing students' learning motivation. That is, applying a scientific numeracy literacy-based learning approach significantly positively affects students' enthusiasm and engagement in learning. Theoretically, these results support previous research, which confirms that a scientific numeracy literacy-based approach can improve concept understanding and material relevance and provide a more meaningful learning experience for students. This approach provides better cognitive understanding and motivates students to be more active in exploring learning materials. Suhendi et al. (2021) state that the theory of constructivism states that meaningful learning occurs when students actively build their knowledge based on direct experience.

In addition, this finding is also relevant to the concept of andragogy in higher education, where students as adult learners tend to be more motivated when the material they learn has relevance to real life and can be applied in a professional context. Teaching materials based on scientific numeracy literacy provide opportunities for students to develop analytical and critical skills needed in the academic and professional world. Thus, applying scientific-based numeracy literacy teaching materials in learning management significantly positively impacts student learning motivation. Therefore, to improve the quality of learning, educators are advised to continue to innovate in developing learning strategies that can increase student involvement and enthusiasm, thus creating a more effective and meaningful learning environment.

Based on the results of hypothesis testing using the independent sample t-test shown in Table 9, it is found that the Sig (2-tailed) value is 0.000, which is smaller than 0.05. This shows a significant difference between students' average higher-order thinking skills in the experimental and control groups. This shows a significant difference between students' average higher-order thinking skills in the experimental and control groups. In other words, the use of scientific-based numeracy literacy teaching materials in learning management has a significant effect on improving students' higher-order thinking skills. The t-test results showed that the experimental group using scientific-based numeracy literacy teaching materials had a higher average score of higher-level thinking skills than the control group. The 'Mean Difference' value of 15.30719 shows the difference in the average post-test score between the experimental and control groups. With a 95% confidence interval (12.7625 to 17.8519), these results further strengthen the finding that innovative teaching materials can significantly improve students' higher-order thinking skills. Theoretically, these results are supported by the research of Rangkuti et al. (2024), which revealed that scientific-based numeracy literacy plays an important role in developing higher-order thinking skills, such as analysis, evaluation, and synthesis of information. This approach allows students to develop a more systematic mindset in solving problems and improve their ability to apply academic concepts to real-world situations. Research by Rohmah et al. (2022) also revealed that students are given numerical literacy inculcation in Mathematics learning, which will later be trained to think at a higher level.

In the context of higher education, higher-order thinking is an essential skill that students must have to face future academic and professional challenges. The scientific numeracy literacy-based approach improves concept understanding and helps students develop critical and creative thinking skills. This is in line with the statement of Suhendi et al. (2021), which reveals that the theory of constructivism states that effective learning occurs when students actively build their knowledge based on experience and involvement in deep thinking processes. Thus, applying scientific-based numeracy literacy teaching materials in learning management significantly positively impacts students' higher-order thinking skills. Therefore, educators are advised to continue developing innovative learning strategies to increase students' involvement in more complex thinking processes, thus creating a more effective and meaningful learning environment.

The scientific approach in developing numeracy literacy teaching materials can encourage students to hone higher-order thinking skills, such as analysis, evaluation, and synthesis. Using science-based teaching materials improves students' conceptual understanding and increases their learning motivation in learning management. This presentation is in line with the results of Yáñez de Aldecoa & Gómez-Trigueros (2022), which revealed that teaching materials designed with a numeracy literacy approach can help students understand basic concepts and use them in a variety of more challenging situations. For example, students are invited to solve problems that require critical thinking, connect numerical concepts to everyday life, and consider various possible solutions. This way, their understanding of the material becomes deeper while training their logical and systematic thinking skills.

This improvement in higher-order thinking skills can also be attributed to problem-based learning, often combined with a scientific approach. When students face real problems that require creative solutions, they must apply various problem-solving strategies, thus strengthening their thinking skills (Loyens et al., 2023; Schaller et al., 2023). This presentation is in line with the research of Syamsuddin et al. (2023), which revealed that numeracy literacy teaching materials based on the scientific approach serve as a tool to improve students' numeracy knowledge and as a means to develop their critical and creative thinking skills.

Using a scientific approach to numeracy literacy learning allows for a more in-depth learning experience and provides opportunities for students to improve their metacognitive skills (Rangkuti et al., 2024; Termaat, 2024). Metacognition, or the ability to reflect on and manage one's thinking, plays a crucial role in learning that involves solving complex problems. When students face challenges that require in-depth analysis and evaluation of options, they gradually develop strategies to monitor and control their thought processes. This helps students become more aware of their learning methods, which can improve their effectiveness and efficiency in solving problems (Triwahyuningtyas & Sesanti, 2023).

The enhanced motivation through the numeracy literacy approach is also supported by learning elements that are more contextualized and relevant to students' real lives. Using real-life examples and practical applications in the teaching materials, students can see how the numeracy skills they learn can be applied in the real world. This makes learning more engaging and provides a sense of purpose and relevance, which is important in building long-term motivation. Students who see real value in what they are learning tend to stay motivated and engaged in the learning process, even when facing complex challenges (Amin et al., 2022; Fischer & Brückner, 2024; Glüer-Pagin & Spectre, 2024). Another aspect to note is how this scientific approach also supports differentiation of learning, which allows teaching materials to be tailored to different student ability levels (Fatmawati et al., 2022; Subali et al., 2019). Thus, students with difficulty understanding certain concepts can be given additional support through a more visual or practical approach. In contrast, more advanced students can be given additional challenges, encouraging them to think more deeply. This differentiation is important to ensure that every student, regardless of ability level, can develop higher-order thinking skills (Handayani et al., 2024; Kurniawan et al., 2024; Walter, 2024).

In this study, using science-based numeracy literacy teaching materials in learning management significantly impacted student involvement in the learning process. Learning became more effective, especially in the aspect of sociocognitive interaction. This can be seen from the increasing ability of students to ask questions, work together, and discuss in groups. In addition, their curiosity increases, the ability to explain the concepts of the discussion results gets better, assignments and exercises are completed more optimally, and students are more enthusiastic about working on problems or solving the problems given (Firoozi et al., 2017; Mundelsee & Jurkowski, 2021; Näykki et al., 2021). These positive influences directly impact improving students' higher-order thinking skills and student learning outcomes (Iancu, 2014; Lu et al., 2021).

The success of this study is supported by previous research, including Amali et al. (2022), who revealed that the benefits of higher-order thinking skills (HOTS) assessment include increased student learning motivation. This happens because HOTS assessment links the material learned in class with real-world situations, making learning more meaningful. Research by Kurniawan et al. (2021) and Nowlan et al. (2023)

also revealed that HOTS assessment can improve student learning outcomes by training them to think creatively and critically rather than simply remembering, repeating, or reciting information without processing it. Measuring higher-order thinking skills can improve students' academic achievement, enabling them to compete nationally and internationally. Research by Mohamed & Lebar (2017) and Saputri et al. (2019) also revealed that assessments that test students' higher-order thinking skills (HOTS) include various aspects, such as critical thinking, logical, reflective, metacognitive, creative, and non-routine skills. In addition, these assessments also emphasize problem-solving that does not rely on algorithms, analytical skills, evaluation, and the creation of new ideas. This process involves concept development, critical thinking, creativity, brainstorming, problem-solving, mental representation, rule application, reasoning, and logical thinking. Thus, applying science-based numeracy literacy teaching materials in learning management can increase students' motivation and higher-order thinking skills.

Overall, applying numeracy literacy textbooks based on the scientific approach to learning significantly impacts students' learning motivation and higher-order thinking skills. This approach emphasizes the importance of student-centered learning, where students are actively involved in the learning process and encouraged to think critically and creatively. Thus, the scientific approach improves academic achievement and prepares students to become lifelong learners who can adapt to changes and face challenges in the globalization era. Thus, this study shows that using science-based numeracy literacy teaching materials in learning management significantly impacts students' motivation and higher-order thinking skills. Teaching materials designed to develop numeracy literacy help increase students' learning motivation while strengthening their ability to think critically and analytically.

The results show that students using science-based teaching materials are more enthusiastic and active in learning. They are more confident in asking questions, exploring material concepts, and applying the knowledge gained in everyday life. In addition, the increase in higher-order thinking skills can be seen in their ability to solve complex problems, make generalizations, and evaluate information. These skills are helpful in the academic field and play an important role in preparing students to face real-world challenges. Overall, the findings of this study suggest that integrating science-based numeracy literacy teaching materials not only increases student motivation but also contributes to the development of higher-order thinking skills, which in turn can create a more critical and creative generation. Therefore, educators need to consider using teaching materials aligned with scientific principles to improve the quality of learning and student achievement.

This research was conducted at Quality University Medan to examine the effect of using science-based numeracy literacy teaching materials in learning management on students' motivation and higher-order thinking skills. The results revealed that the teaching materials were able to have a positive influence in increasing students' engagement in the learning process, encouraging intrinsic motivation, as well as developing their higher-order thinking skills. These findings suggest that a science-based approach has great potential to support higher education learning. However, as this study was only conducted at Quality University, there are limitations in generalizing the results. Factors such as student characteristics, academic culture, and the educational environment at the university may differ from other institutions, locally, nationally, and internationally. These differences may affect the teaching materials' implementation and impact, so the research results must be applied in other contexts with caution.

To assess the relevance and applicability of these findings in different settings, it is necessary to consider aspects such as differences in curricula, teacher preparedness, and student backgrounds. This article should present an in-depth analysis of how the research findings can be adapted or applied to other populations, including different levels of education, institutions with diverse resources, and environments with unique academic cultures. Therefore, although this study's results significantly contribute to the development of science-based teaching materials, a more in-depth explanation of the limitations of the context and the potential for its application in other settings is needed. This step will not only increase the academic value of the study but also open up opportunities for further research exploring the effectiveness of these teaching materials in various educational contexts.

CONCLUSION

The results showed that using scientific-based numeracy literacy teaching materials significantly improved students' learning motivation and higher-order thinking skills. This finding confirms the importance of the scientific approach in developing teaching materials to encourage students' engagement and critical thinking skills. This research contributes to enriching learning management practices by proposing a teaching material model that supports numeracy literacy contextually. Teachers, curriculum developers, and policymakers can utilize these results to design learning that is more meaningful and adaptive to the needs of the 21st century. The study's limitations lie in the scope of the sample and the local context. Further research is recommended with a broader scope and a more in-depth approach to test the consistency of the impact of these teaching materials across different learning environments.

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