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Developing an Ethno Mandailing-Realistic Mathematics Education Model Assisted by Adobe After Effects to Improve Numeracy Literacy of Elementary School Students

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Abstract

This study developed the Ethno Mandailing-Realistic Mathematics Education (Ethno Mandailing-RME) Model, assisted by Adobe After Effects, to improve elementary school students' numeracy literacy skills by integrating local Mandailing culture, especially Bagas Godang and Sopo Godang, into realistic mathematics learning through visual animation media. The study used a research and development approach based on the Plomp model, which includes the initial investigation, design, development, implementation, and evaluation stages, involving 125 fifth-grade students from three public elementary schools in Mandailing Natal Regency, comprising 69 students in the experimental class and 56 in the control class. The results of expert validation showed that the developed model was in the very valid category with an average score of 4.58. At the same time, the practicality aspect was reflected in the high teacher response rate (91%), student response rate (89%), and learning implementation rate (93%). The effectiveness test showed that the experimental class achieved higher average posttest and N-Gain scores than the control class, and statistical analysis confirmed a significant difference in numeracy literacy improvement. Thus, the Ethno Mandailing-RME Model, assisted by Adobe After Effects, has been proven valid, practical, and effective in improving numeracy literacy skills among elementary school students.

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Introduction

Technological developments and the Industrial Revolution 5.0 demand strengthening 21st-century competencies, particularly numeracy literacy, as it encompasses the ability to calculate, think critically, solve problems, understand data, and make decisions in everyday life (OECD, 2022). The Independent Curriculum positions numeracy literacy as an essential competency that needs to be developed from elementary school onward so that students can adaptively and contextually face global challenges. However, Indonesian students' numeracy literacy achievement remains low, as demonstrated by the 2022 PISA results, which ranked Indonesia 74th out of 81 countries with a mathematics score of 376, below the OECD average of 472 (OECD, 2022). The 2023 National Assessment also showed that only around 32% of students achieved minimum numeracy competency (Pusmenjar, 2023).

The problem of numeracy literacy is inseparable from the mathematics learning process in schools, which is still abstract, procedural, and teacher-centered. Mathematics learning tends to emphasize formula memorization and mechanistic solutions without connecting concepts to students' real-life experiences. As a result, students have difficulty understanding mathematical concepts, particularly geometry, which requires visualization and spatial understanding. Based on observations in several elementary schools in East Panyabungan District, most students are unable to connect geometric shapes to real objects around them. Furthermore, the lack of contextual learning causes students to view mathematics as a difficult subject and meaningless in everyday life. The finding reinforces the condition that approximately 67% of mathematics problems in textbooks are not related to students' lives (NCTM, 2023).

Realistic Mathematics Education (RME) is a strategic approach to addressing abstract and procedural mathematics learning by using real-world contexts as a basis for concept formation. This approach enables elementary school students to build understanding from concrete experiences to formal concepts through horizontal and vertical mathematization (Sembiring et al., 2008; Prahmana, 2022). RME also enhances active participation, problem-solving, mathematical literacy, contextual reasoning, visualization, modeling, conceptual understanding, positive attitudes, statistical literacy, and critical thinking (Revina & Leung, 2019; Tong et al., 2022; Juandi et al., 2022; Fauzan et al., 2024; Palinussa et al., 2021; Hakim & Setyaningrum, 2024).

The RME approach, combined with Mandailing ethnomathematics, enables meaningful, culturally grounded mathematics learning. Ethnomathematics examines mathematical practices in community cultural activities (Rosa & Orey, 2023). Bagas Godang and Sopo Godang incorporate geometric concepts, such as triangles, trapezoids, prisms, pyramids, and cubes, as well as symmetry, making them relevant as learning resources. This integration supports the construction of concepts through students' real-life experiences. Findings by Ritonga et al. (2025) and Prahmana (2022) indicate improved reasoning, engagement, and cultural identity, in line with Pratama & Yelken (2024), Purniati et al. (2022), and Sutarto et al. (2022).

The RME approach, combined with ethnomathematics, emphasizes mathematics learning as a contextual, meaningful process rooted in local culture. According to Rosa and Orey (2023), ethnomathematics examines

mathematical practices within specific cultural communities. In Mandailing culture, Bagas Godang and Sopo Godang incorporate the concepts of triangles, trapezoids, prisms, pyramids, cubes, symmetry, rhombuses, and rectangles, making them relevant as concrete media for geometry learning. The integration of local culture supports logical thinking, learning engagement, mathematical literacy, metacognition, and students' cultural identity (Ritonga et al., 2025; Prahmana, 2022; Pratama and Yelken, 2024; Purniati et al., 2022; Sari et al., 2022; Sutarto et al., 2022; Utami et al., 2021; Wibawa et al., 2025).

Although extensive research has been conducted on the effectiveness of Realistic Mathematics Education (RME) in improving mathematics learning outcomes and numeracy literacy (Juandi et al., 2022; Tong et al., 2022), and ethnomathematics studies in mathematics learning continue to develop (Rosa & Orey, 2023; Prahmana, 2022), the integration of Mandailing ethnomathematics-based RME with Adobe After Effects (AAE) animation media to improve elementary school students' numeracy literacy remains very limited. Most research still focuses on the RME approach without a local cultural context, while ethnomathematics research has not yet utilized interactive multimedia. Therefore, the development of innovative learning models that integrate local culture, animation technology, and numeracy literacy in a contextually and systematically integrated manner is necessary.

The novelty of this research lies in the development of the Ethno Mandailing-RME model, supported by AAE animations that integrate Mandailing ethnomathematics, a realistic mathematics approach, and interactive multimedia technology to improve elementary school students' numeracy literacy. This model is designed contextually and culturally so that it can connect mathematical concepts with students' real experiences through Mandailing cultural artifacts. In addition to improving numeracy skills, this model also strengthens students' cultural identity and digital literacy. This research aims to develop the validity, practicality, and effectiveness of the learning model in improving elementary school students' numeracy literacy.

Method

Research Design

This study uses the Plomp model R&D approach, including initial investigation, design, development, implementation, and evaluation, to produce a Mandailing ethnomathematics-based RME model assisted by Adobe After Effects. The integration of local cultural context is designed to strengthen the connection between abstract mathematical concepts and students' real-life experiences, thereby supporting numeracy literacy, conceptual understanding, and meaningful problem-solving (Plomp, 2013; Sembiring et al., 2008; Rosa & Orey, 2023).

Participants

This study involved 125 fifth-grade students from three public elementary schools in Mandailing Natal Regency, who were purposively selected based on the suitability of the subject's characteristics to the research objectives (Sugiyono). The sample consisted of 69 students from the experimental class and 56 students from the control class to test the effectiveness of AAE-assisted Ethno Mandailing-RME learning compared to conventional learning.

Research Instruments

Research instruments, including tests and non-tests, were used to collect valid and reliable data to assess the validity, practicality, and effectiveness of the developed learning model (Sugiyono, 2019).

Numeracy Literacy Test

The numeracy literacy test was administered as a pretest and posttest to both the experimental and control groups. The pretest was used to identify students' initial numeracy literacy abilities, whereas the posttest was used to determine students' achievement after the learning intervention. The test results were subsequently analyzed to obtain mean scores, N-Gain values, classical learning mastery, and inferential statistical evidence of learning effectiveness.

Validation Instrument

Validation instruments are used to assess the suitability of learning models, teaching materials, worksheets, and teacher and student books through expert assessments of material, learning design, language, and educational evaluation by paying attention to aspects of content, construction, language, presentation, and suitability of learning objectives so that theoretically and empirically valid instruments are obtained.

Observation Instrument

The observation instrument focused on student learning activities and teacher competencies in implementing the Ethno Mandailing-RME Model. Student activities included contextual problem exploration, mathematical representation, collaborative discussion, and conclusion drawing. In contrast, teacher competencies included facilitating mathematization, managing classroom interactions, using AAE media, and reflecting on contextual learning grounded in Mandailing culture (Sembiring et al., 2008; Rosa & Orey, 2023).

Questionnaire Instrument

The questionnaire instrument was used to obtain data on teacher and student responses to the developed learning model. The questionnaire was compiled on a Likert scale to measure the practicality, ease of use, attractiveness, and user acceptance of the Mandailing ethnomathematics-based learning model. The questionnaire data served as a basis for assessing the practicality of the product being developed.

Development Procedures

The development procedures in this study refer to the Plomp model, which consists of the following five stages:

Preliminary Investigation: The preliminary investigation phase was conducted to identify mathematics learning

needs, students' numeracy literacy skills, and relevant Mandailing cultural potential through observation, interviews, curriculum analysis, and literature studies. The results of the investigation served as the basis for developing a learning model specification grounded in RME, ethnomathematics, and numeracy literacy, in a contextually and empirically informed manner.

Design: The design phase aimed to develop an initial prototype of the learning model and its supporting tools. Activities at this stage included developing the syntax of the learning model, designing teaching modules, Student Worksheets, Model' books, teacher's books, students' books, and AAE-based learning media. The development design was based on the principles of RME and the Mandailing ethnomathematics approach, as well as the established learning outcomes.

Development: The development stage includes the preparation of the initial product, validation by material experts, design, language, and evaluation, as well as revisions based on input from validators to produce models, tools, media, and research instruments that meet content, construct, and conceptual validity before being implemented in the trial stage.

Implementation: The implementation stage involved limited trials and field trials with fifth-grade elementary school students. The purpose of implementation was to obtain data on the practicality and effectiveness of the developed learning model in improving students' numeracy literacy skills. At this stage, the Realistic Mathematics Education (RME)-based learning model and Mandailing ethnomathematics were implemented in the mathematics learning process, accompanied by observations of student activities, the implementation of learning, and user responses to the developed product.

Evaluation: Evaluation is carried out continuously through formative and summative assessments to assess the validity, practicality, and effectiveness of the product, to improve the contextual quality of elementary school mathematics learning.

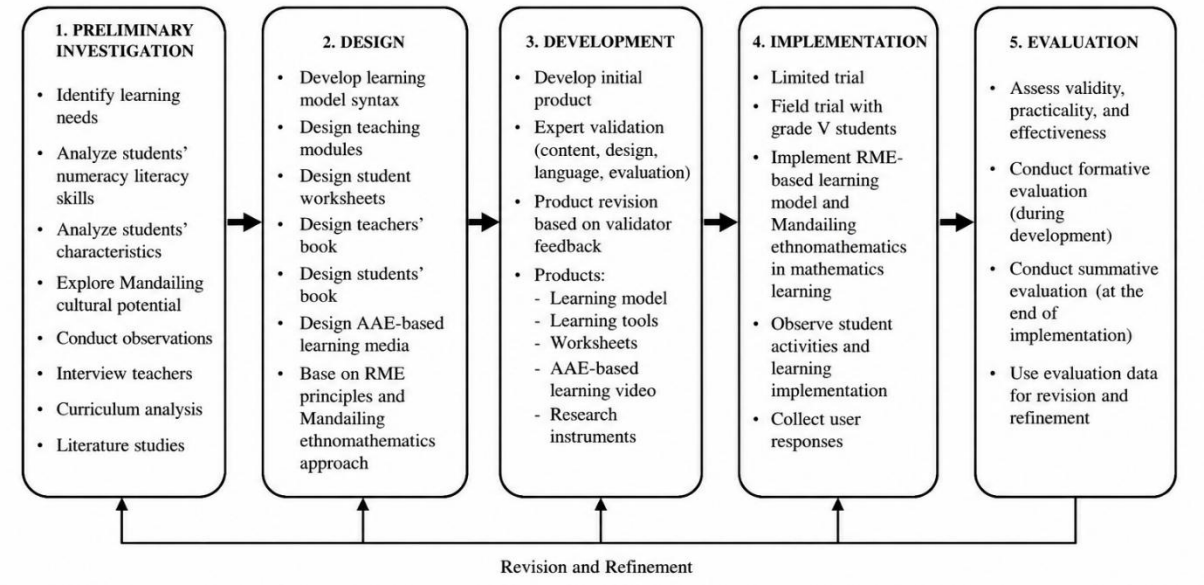


Figure 1. Procedure for Developing the Plomp Model in Research

Data Analysis Technique

Data analysis techniques were used to assess the validity, practicality, and effectiveness of the model through quantitative and qualitative data analysis, including expert validation, observation, questionnaires, N-Gain, classical completeness, and inferential statistical tests (Sugiyono, 2019).

Validity Analysis

The validity analysis of the learning model and tools was carried out through expert assessment using a Likert scale instrument, then analyzed based on the average score for each aspect to determine the product validity category.

Practicality Analysis

Practicality analysis was conducted through learning observations and teacher and student response questionnaires to assess the implementation of syntax, ease of use, and acceptance of the RME Mandailing ethnomathematics learning model effectively and applicably.

Effectiveness Analysis

The effectiveness of the Ethno Mandailing-RME Model is demonstrated through increased numeracy literacy, N-Gain scores, completion of classical tasks, student activities, and contextual learning management.

N-Gain Analysis

N-Gain analysis was used to determine the level of improvement in students' numeracy literacy skills before and after implementing the learning model. Data were obtained from pretest and posttest results, which were analyzed using the normalized gain formula:

$$N - Gain = \frac{Posttest - Pretest}{Maximum\ score - Pretest} \quad (1)$$

N-Gain results are classified into high, medium, and low categories to measure increases in students' numeracy literacy. At the same time, classical completion is determined by the percentage of students who meet the Minimum Mastery Criteria (MMC). The learning model is declared effective if the experimental class shows higher improvement and completeness than the control class (Hake, 1999).

Hypothesis Testing

Hypothesis testing was conducted using normality and homogeneity tests, paired-samples and independent-samples t-tests at a significance level of 0.05, in Python, to analyze the effect of the AAE-assisted Ethno Mandailing-RME model on students' numeracy literacy. Descriptive percentage analysis was used to evaluate student activities, teacher learning management, practicality, and effectiveness of the developed learning model.

Results

Preliminary Investigation

Initial investigations indicate that students' numeracy literacy skills in three elementary schools remain low, particularly in understanding geometric concepts, interpreting mathematical symbols, and solving contextual problems. This finding aligns with the results of the 2022 PISA (Page 11) and the National Assessment, which show that Indonesian students' numeracy achievement remains below OECD standards. These findings underscore the urgency of developing contextual, visual, and experiential mathematics learning (OECD, 2022; Pusmenjar, 2023). The needs analysis indicates the urgency of developing a contextual, visual, and culturally based elementary school mathematics learning model to address the gap between procedural teaching and students' empirical numeracy needs (Landong et al., 2025). Field findings are presented in Table 1.

Table 1. Initial Observation Indicators (Needs Analysis)

Observation Aspects	Field Findings	Implications for Learning
Numeracy Literacy	Students have difficulty understanding the concepts of area and volume in real contexts.	Contextual learning based on student experience is needed.
Teacher Strategies	Learning still predominantly uses lecture methods and procedural exercises	Learning models that encourage exploration and mathematization are needed
Cultural Integration	Mandailing culture has not been utilized as a context for mathematics learning	Ethnomathematics needs to be integrated into learning.
Learning Media	Visual media and learning technology are still limited	Visual and animation-based media such as AAE are needed
Student Activities	Students tend to be passive and dependent on the teacher.	Collaborative and exploratory activities based on RME are needed.

Initial findings from Table 1 indicate the dominance of lectures and procedural exercises, low integration of Mandailing culture, and limited visual media; this condition emphasizes the gap between students' needs for concrete mathematical experiences and abstract learning practices, so that realistic context-based models, Mandailing cultural artifacts, and technological visual media are needed to strengthen numeracy literacy meaningfully.

The results of structured observations indicate that the quality of mathematics learning at SDN 127 Pagur, SDN 130 Ranto Natas, and SDN 131 Tanjung remains suboptimal. SDN 127 Pagur is sufficient in realistic contexts, discussions, and problem understanding, but low in Mandailing cultural integration, student strategies, mathematical representation, and animated media. SDN 130 Ranto Natas is low in almost all indicators, even very low in animated media. SDN 131 Tanjung Julu is sufficient in several aspects, but very low in cultural and media integration. These findings emphasize the need for mathematics learning that is more contextual, exploratory,

representational, based on Mandailing culture, and supported by animated media. The results of interviews at the three research schools are given in Table 2.

Table 2. The Results of Interviews at the Three Research Schools

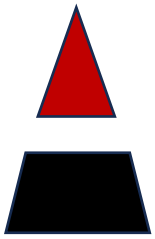
School	Number of students	Interview sample	Basis for sample selection	Data focus
SDN 127 Pagur Village	22	6 students	2 high, 2 medium, 2 low	Numeracy literacy
SDN 130 Ranto Natas Village	24	6 students	2 high, 2 medium, 2 low	Numeracy literacy
SDN 131 Tanjung Village	23	6 students	2 high, 2 medium, 2 low	Numeracy literacy

Table 2 emphasizes the need for a learning model that adapts to diverse student abilities by actively involving students in solving numeracy literacy problems. The Mandailing cultural context, particularly Bagas Godang and Sopo Godang, is relevant to mathematics learning because it incorporates geometric concepts such as triangles, trapezoids, prisms, pyramids, symmetry, and transformations. From an RME perspective, cultural artifacts serve as realistic media that encourage horizontal mathematization toward meaningful formal representations. This finding aligns with Prahmana (2022), Rosa and Orey (2023), and Pratama and Yelken (2024). Therefore, the geometric elements of Bagas Godang are shown in Figure 2.

Figure 2. Bagas and Sopo Godang Panyabungan Tonga

The cultural ornaments in Table 3 serve as the basis for developing an AAE-based animated video to dynamically, interactively, and contextually visualize geometric concepts, thereby supporting more humanistic, visual, and meaningful mathematics learning.

Table 3. Bagas Godang Mandailing Ornaments

Ornament Shape	Name Ornament	Meaning	Shape Mathematics
	Bindu or rib robung	Bindu, or bamboo shoots, are young bamboo shoots. Large bamboo shoots, in particular, can be used as food (vegetables). Bamboo shoots symbolize growth, and the Dalihan Na Tolu tradition serves as a foundation for a culture that can lead society forward and benefit others.	

Development of Ethno Mandailing-RME Model

The development phase resulted in the Ethno Mandailing-RME Model, supported by Adobe After Effects, which integrates Realistic Mathematics Education, Mandailing ethnomathematics, and digital animation into contextual learning. The model's syntax includes cultural exploration, discussion, mathematization, reflection, and collaboration. Figure 3 shows local culture as the primary context for developing students' numeracy literacy (Prahmana, 2022; Rosa & Orey, 2023).

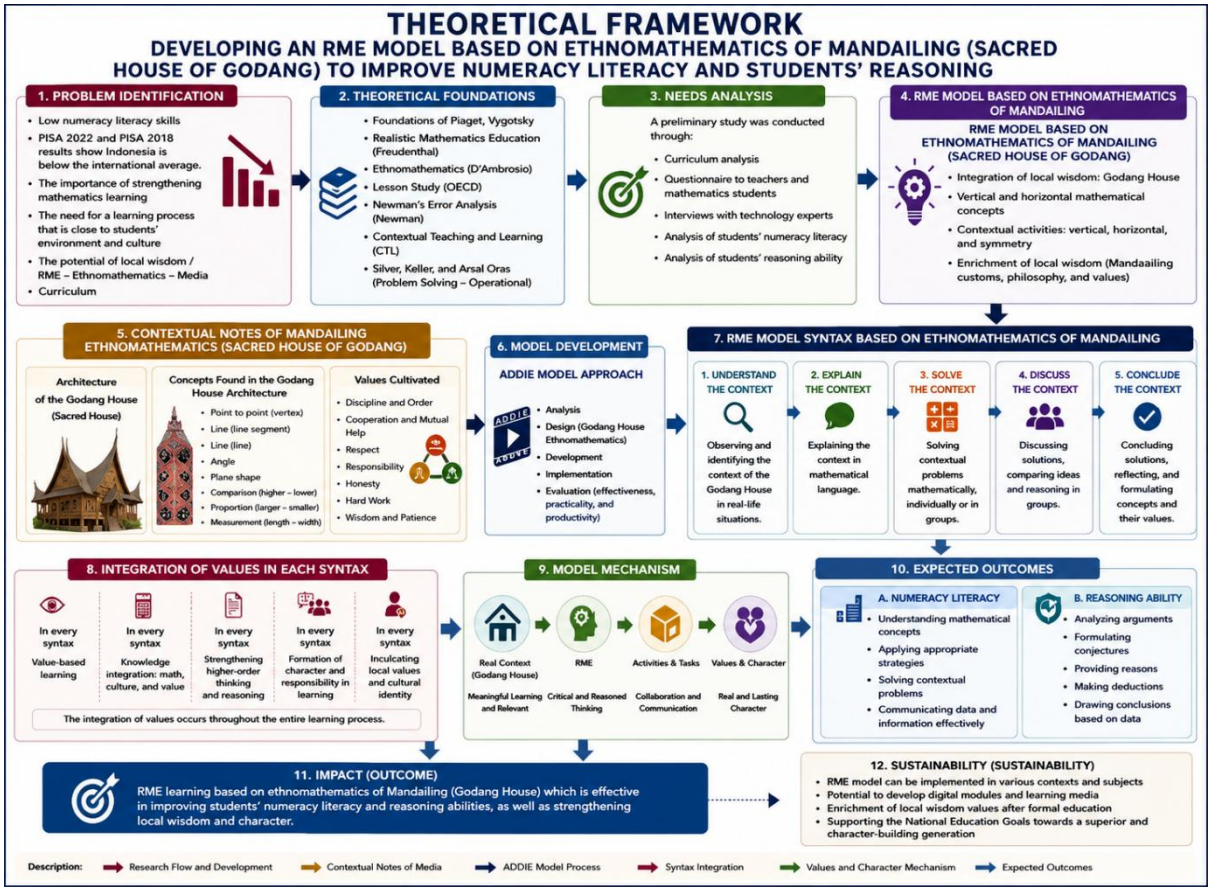


Figure 3. Ethno Mandailing-RME Development Model

Figure 4 shows the syntax of the Ethno Mandailing-RME Model, which consists of five learning phases: understanding contextual problems, exploring problems, solving problems collaboratively, comparing and discussing solutions, and formulating mathematical conclusions. This model integrates Mandailing culture as a learning context to support horizontal and vertical mathematization processes, enabling students to build reasoning, representation, and numeracy literacy in a contextual, meaningful, and real-life context.

The validation results show that the Ethno Mandailing-RME Model is in the very valid category with a material expert score of 4.61, media expert 4.54, language expert 4.49, and model feasibility 4.58, so it is worthy of being implemented in elementary school mathematics learning based on numeracy literacy and visualization of Mandailing culture through AAE.

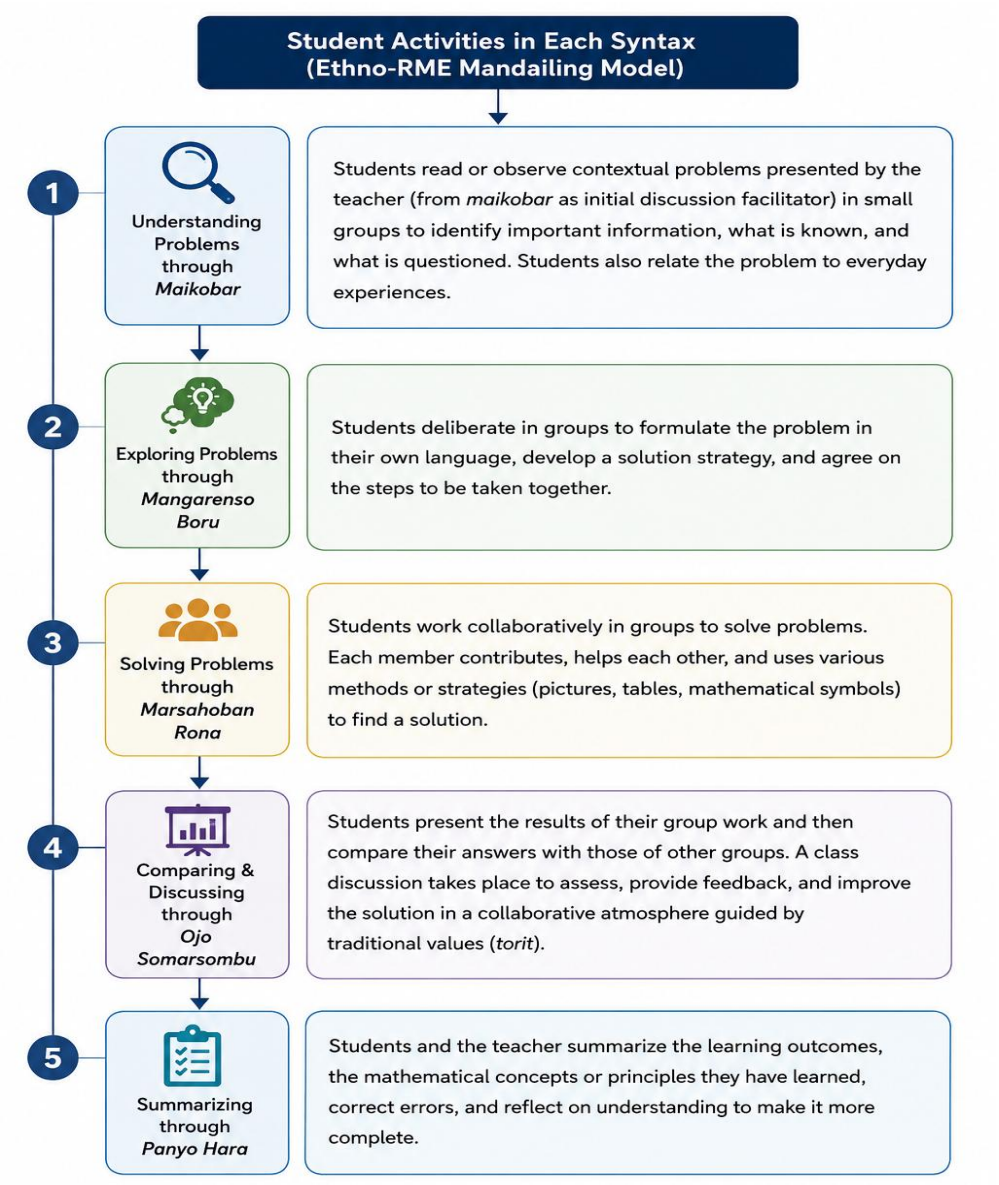


Figure 4. Syntax of the Mandailing Ethno-RME Model

Validation Results

Expert validation was conducted to evaluate the feasibility of the learning model, learning tools, student worksheets, and Adobe After Effects-based media in terms of content, media design, language, and model construction.

Table 4. Expert Validation Results

Aspect	Score	Category
Material Expert	4.61	Very Valid
Media Expert	4.54	Very Valid
Language Expert	4.49	Very Valid
Model Feasibility	4.58	Very Valid

The validation results showed that all assessed components were categorized as very valid. The material expert score of 4.61 indicated that the mathematical content was consistent with the learning outcomes and numeracy literacy indicators. The media expert score of 4.54 showed that the Adobe After Effects animation was suitable for visualizing abstract geometric concepts. The language expert score of 4.49 indicated that the instructions and learning materials were understandable for elementary school students. The overall model feasibility score of 4.58 confirmed that the developed model met the requirements for implementation in the field trial.

Practicality Results

The practicality of the learning model was measured through teacher responses, student responses, and the feasibility of learning during the implementation of the Mandailing Ethno-RME model, as shown in Table 5.

Table 5. Results of Model Practicality

Component	Percentage	Category
Teacher Response	91%	Very Practical
Student Response	89%	Very Practical
Learning Implementation	93%	Very Practical

The practicality results showed that the Ethno Mandailing-RME Model was highly applicable in classroom instruction. Teacher responses reached 91%, student responses reached 89%, and learning implementation reached 93%, all categorized as very practical. These findings indicate that the model syntax, teaching materials, student worksheets, and AAE-based media were feasible for teachers to use and acceptable to students during mathematics learning.

Effectiveness Results

The effectiveness of the Ethno Mandailing-RME Model was examined using pretest and posttest scores, N-Gain values, classical learning mastery, and inferential statistical tests, as presented in Table 6.

Table 6. Statistical Description of Research Results

Class	Mean Pretest	Mean Posttest	Mean N-Gain	Category
Experiment	62.54	82.46	0.51	Medium
Control	59.05	69.88	0.24	Low

The experimental class demonstrated greater improvement than the control class. The mean score of the experimental class increased from 62.54 to 82.46, with an N-Gain of 0.51 in the medium category. In comparison, the control class increased from 59.05 to 69.88, with an N-Gain of 0.24 in the low category. These results indicate that the Ethno Mandailing-RME Model assisted by Adobe After Effects produced stronger numeracy literacy improvement than conventional instruction. Prior to conducting the hypothesis testing, the data were analyzed for normality and homogeneity to ensure that the assumptions of parametric statistics were fulfilled.

The results of the normality and homogeneity tests are presented in Tables 7 and 8.

Table 7. Normality Test Results

Data	Sig.	Description
Pretest Experiment	1.	Normal
Posttest Experiment	1.	Normal
N-Gain Experiment	0.8	Normal
Control N-Gain	0.62	Normal

Table 8. Homogeneity Test Results

Data	Sig.	Description
Experimental and Control N-Gain	0.54	Homogeneous

The statistical test results are shown in Table 9.

Table 9. Statistical Test Results

Test Type	Sig.	Conclusion
Paired Sample t-Test	0.000	There is a significant increase
Independent Sample t-Test	0.000	There is a significant difference between the experimental and control classes
N-Gain Test	0.51	Moderate Category

Table 10 shows that the paired-samples t-test and independent-samples t-test produced significance values below 0.05, indicating a significant increase in students' numeracy literacy after implementation and a significant difference between the experimental and control classes.

Table 10. Paired Sample t-Test Results

Class	Mean Pretest	Mean Posttest	Sig.	Conclusions
Experiment	62.54	82.46	0	There was a significant difference between the pretest and posttest in the experimental class
Control	59.05	69.88	<0.001	There was a significant difference between the pretest and posttest in the control class.

Table 11. Independent Sample t-Test Results

Class	Mean N-Gain	SD	Sig.	Conclusions
Experiment	0.51	5.81	5.32×10^{-13}	There is a significant difference in the effectiveness of the Mandailing ethnomathematics-based RME model
Control	0.24	5.56	5.32×10^{-13}	There is a significant difference in the effectiveness of the Mandailing ethnomathematics-based RME model.

The statistical findings confirm that the Ethno Mandailing-RME Model assisted by AAE had a significant effect on improving elementary school students' numeracy literacy. Figures 5, 6, and 7 show the pattern of pretest and posttest score increases in each school. Visually, almost all students experienced an increase in their scores after the implementation, indicating that this model had a positive impact on various student characteristics in the three different schools.

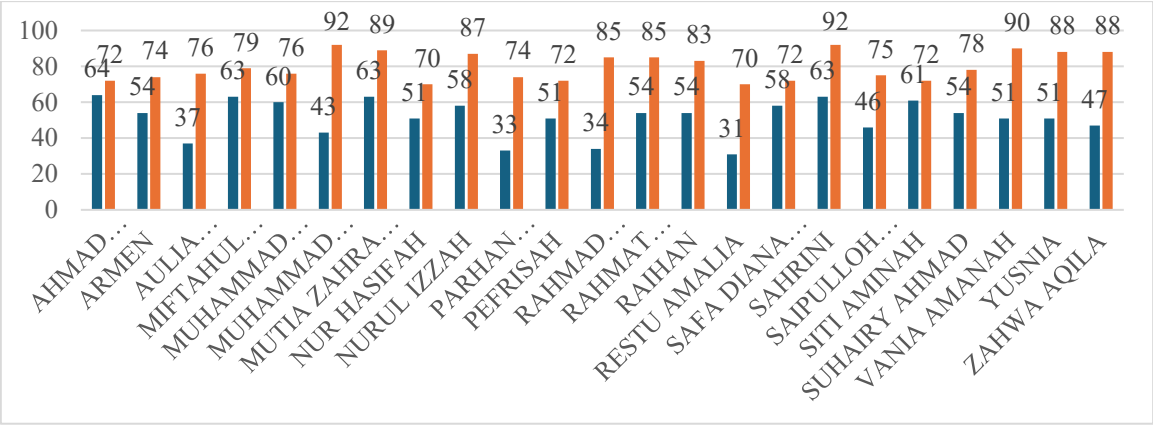


Figure 5. Bar Chart Comparing Pretest and Posttest Scores of Students at SDN 131 Tanjung

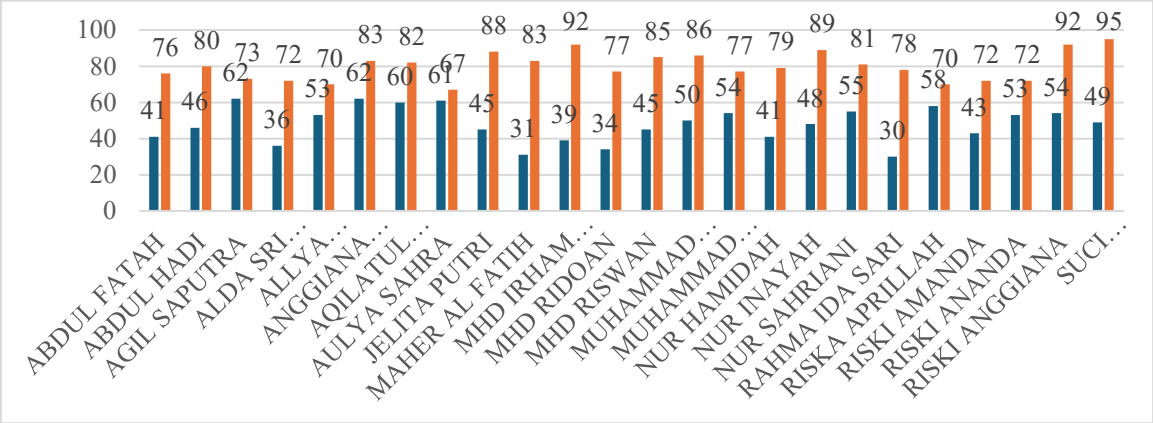


Figure 6. Bar Chart Comparing Pretest and Posttest Scores of Students at SDN 130 Ranto Natas Village

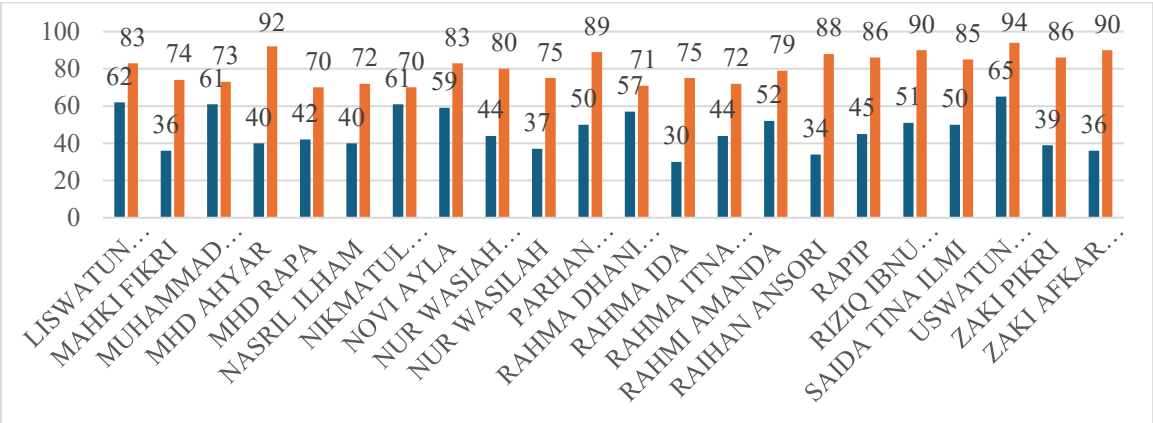


Figure 7. Bar Chart Comparing Pretest and Posttest Scores for Students at SDN 127 Pagur Village

Figure 8 reinforces this finding by showing that the experimental class's posttest average was higher than that of the control class.

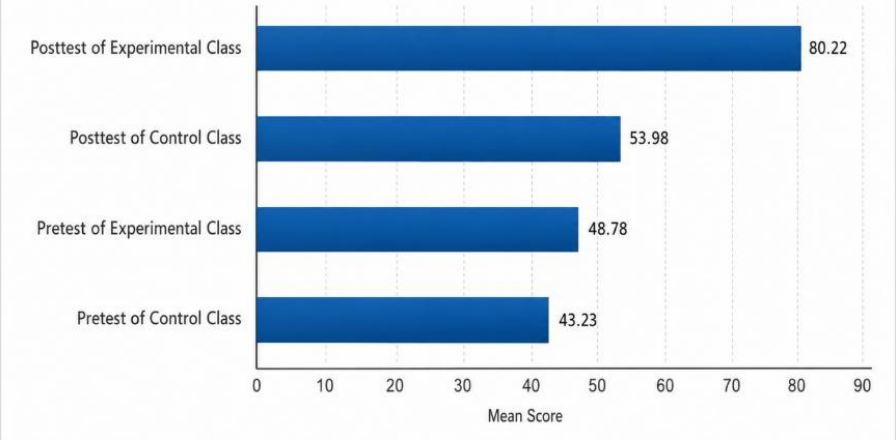


Figure 8. Bar Chart of the Average Increase in Numeracy Literacy Skills

Furthermore, the effectiveness of the model was also examined through classical learning mastery. Students were categorized as having achieved mastery when their posttest scores met or exceeded the school's minimum mastery criterion

Table 12. Classical Learning Mastery Results

Class	Number of Students Achieving Mastery	Percentage	Category
Experiment	61	88.41%	Completed
Experiment	8	11.59%	Not Completed
Control	46	17.86%	Completed
Control	10	82.14%	Not Completed

The classical mastery results showed that 61 students in the experimental class, or 88.41%, achieved mastery, whereas 8 students, or 11.59%, did not. In the control class, the proportion of students who achieved mastery was lower. These findings strengthen the evidence that the Ethno Mandailing-RME Model assisted by AAE supported students in achieving the expected numeracy literacy competencies.

Table 13. Student Activities During the Implementation of the Mandailing Culture-Based Ethno-RME Model

No	Student Activity Aspects	SDN 127 Pagur (%)	SDN 130 Ranto Natas (%)	SDN 131 Tanjung (%)	Category
1	Paying attention to contextual problems presented by the teacher	88	84	86	Very Good
2	Identifying mathematical elements in Mandailing culture	86	82	84	Very Good
3	Actively participating in group discussions	90	85	87	Very Good
4	Expressing ideas or problem-solving strategies	84	80	82	Good

No	Student Activity Aspects	SDN 127 Pagur (%)	SDN 130 Ranto Natas (%)	SDN 131 Tanjung (%)	Category
5	Using mathematical representations (figures, symbols, tables)	87	83	85	Very Good
6	Solving numeracy problems collaboratively	89	84	86	Very Good
7	Presenting group discussion results	85	81	83	Good
8	Drawing conclusions from the mathematics lesson	88	84	85	Very Good
	Average	**87.1**	**82.9**	**84.8**	**Very Good**

Student activity observations in Table 13 showed that the implementation of the Ethno Mandailing-RME Model promoted active learning across the three schools. Students were actively involved in identifying mathematical elements in Mandailing cultural objects, participating in group discussions, using mathematical representations, solving contextual numeracy problems, and presenting group results. The average activity scores at SDN 127 Pagur, SDN 130 Ranto Natas, and SDN 131 Tanjung were 87.1%, 82.9%, and 84.8%, respectively, all categorized as very good.

Table 14. Teachers' Ability in Managing Ethno-RME Learning

No	Teacher Ability Aspects	SDN 127 Pagur (%)	SDN 130 Ranto Natas (%)	SDN 131 Tanjung (%)	Category
1	Opening the lesson and motivating students	92	88	86	Very Good
2	Presenting contextual problems based on Mandailing culture	91	87	89	Very Good
3	Guiding exploration and group discussions	90	86	88	Very Good
4	Managing classroom interaction and student participation	89	85	87	Very Good
5	Effectively utilizing Adobe After Effects media	93	88	86	Very Good
6	Guiding students' mathematization processes	90	86	88	Very Good
7	Providing feedback and reinforcement	91	87	89	Very Good
8	Closing the lesson and conducting reflection	92	88	87	Very Good
	Average	**91.0**	**86.9**	**87.5**	**Very Good**

Observations in Table 14 showed that the implementation of the Ethno Mandailing-RME Model assisted by Adobe After Effects went very well, with teacher management scores reaching 91.0% at SDN 127 Pagur, 86.9% at SDN 130 Ranto Natas, and 87.5% at SDN 131 Tanjung. Teachers were able to effectively facilitate contextual problems, mathematization, discussion, reflection, and the use of media. Overall, the model was deemed valid, practical, and effective in improving students' numeracy literacy, as evidenced by increased posttest scores, a medium N-Gain category, and higher classical completeness.

Discussion and Conclusion

The results of the study indicate that the Ethno Mandailing-RME Model assisted by Adobe After Effects is effective in improving elementary school students' numeracy literacy. This effectiveness is demonstrated by an increase in the average score of the experimental class from 62.54 to 82.46 with an N-Gain of 0.51, while the control class increased from 59.05 to 69.88 with an N-Gain of 0.24. Paired-samples and independent-samples t-tests show significant differences, indicating that the increase in numeracy literacy is related to the application of the model. Pedagogically, the use of Bagas Godang, Sopo Godang, and Mandailing ornaments helps students connect cultural objects with formal mathematical concepts through horizontal and vertical mathematization processes. This finding aligns with Juandi et al. (2022) and Tong et al. (2022), who found that RME supports mathematical literacy through contextual exploration, as well as with Rosa and Orey (2023) and Pratama and Yelken (2024), who found who state that ethnomathematics strengthens understanding through cultural experiences. Student activity was also in the very good category, namely 87.1%, 82.9%, and 84.8% across the three schools, indicating active involvement in discussions, representation, problem-solving, and the presentation of results. Adobe After Effects media strengthens the visualization of abstract geometric concepts, such as shape, area, volume, symmetry, and spatial relations, as supported by Žakelj and Vogrinc (2022), Baihaki et al. (2022), and Chulpongsatorn et al. (2023). The model's validity was also very strong, with scores of 4.61 for material, 4.54 for media, 4.49 for language, and 4.58 for model feasibility. At the same time, practicality was demonstrated in teacher responses (91%), student responses (89%), and learning implementation (93%). Thus, this model is valid, practical, and effective, although its application is still limited to three schools, the Mandailing cultural context, and geometry material.

Based on the research results, the Ethno Mandailing-RME Model, assisted by Adobe After Effects, was found to be valid, practical, and effective in improving numeracy literacy among elementary school students. The validity of the model was demonstrated by expert assessments of the material, media, language, and the model's feasibility, which were rated as very valid. Practicality was reflected in the teacher response (91%), student response (89%), and learning implementation (93%). The model's effectiveness was demonstrated by an increase in the average score of the experimental class from 62.54 to 82.46, with an N-Gain of 0.51 in the moderate category, higher than the control class's 0.24. Statistical tests showed significant differences in learning outcomes, indicating that the increase in numeracy was related to the model's implementation. These findings confirm that integrating Mandailing culture, RME principles, and AAE animation supports meaningful mathematization, collaborative learning, and the strengthening of appreciation for local cultural values among school students.

Based on the research findings, the Ethno Mandailing-RME Model, supported by AAE, is recommended for implementation across diverse elementary school contexts with varying socio-cultural characteristics to test its consistency, adaptability, and effectiveness in mathematics learning. Further research is expected to integrate innovative digital technologies, such as augmented and virtual reality, interactive applications, and game-based media, and to examine the long-term impact of the model on higher-order thinking skills, digital literacy, and the strengthening of culturally responsive mathematics pedagogy in 21st-century learning.

Statements and Declarations

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Supplementary Materials: Supplementary materials supporting this study, including the Ethno Mandailing - RME Model design, Adobe After Effects-based instructional media, student worksheets, validation instruments, and additional statistical analysis results, are available from the corresponding author upon reasonable request.

Author Contributions: Ahmad Landong played a role in conceptualization, model development, research implementation, data analysis, and manuscript preparation; Edy Surya in supervision, methodological design, model validation, data interpretation, and scientific revision; while Yulita Molliq Rangkuti contributed to media development, instrument validation, theoretical review, editing, and finalization of the scientific article.

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Data Availability: The research dataset, including numeracy literacy test results, validation data, observation sheets, questionnaire responses, and learning instruments, is available for academic purposes upon reasonable request. The research was conducted in accordance with ethical standards for educational research with the approval of the institution, school, teachers, and guardians. All student participation was voluntary, in accordance with applicable ethical guidelines.

Informed Consent: Informed consent was obtained from all participants involved in the study, including permission from school authorities, classroom teachers, and the students' parents or legal guardians prior to the implementation of the research procedures. All participants were informed that the data collected would be used solely for academic and research purposes while maintaining the confidentiality and anonymity of participant information throughout the study**.**

Conflicts of Interest: The authors declare that there are no conflicts of interest regarding the publication of this study, including financial, institutional, professional, or personal relationships that could have influenced the research process, data interpretation, or reporting of the findings presented in this manuscript**.**

References

Baihaki, B., Djamilah, S., & Lazwardi, A. (2022). Developing interactive learning media based on Adobe Animate applications for geometry transformation. *Kalamatika: Jurnal Pendidikan Matematika, 7*(2), 191–206. https://doi.org/10.22236/KALAMATIKA.vol7no2.2022pp191-206

Chulpongsatorn, N., Lunding, M. S., Soni, N., & Suzuki, R. (2023). *Augmented Math: Authoring AR-based*

explorable explanations by augmenting static math textbooks. arXiv. https://doi.org/10.48550/arXiv.2307.16112

Fauzan, A., et al. (2024). Realistic mathematics education (RME) to improve literacy and numeracy skills in elementary school students. *Infinity Journal, 13*(1), 1–15.

Hakim, T. A., & Setyaningrum, W. (2024). Realistic mathematics education combined with guided discovery for improving middle school students' statistical literacy. *Journal of Honai Math, 7*(2), 233–246. https://doi.org/10.30862/jhm.v7i2.564

Juandi, D., Kusumah, Y. S., & Tamur, M. (2022). A meta-analysis of the last two decades of realistic mathematics education approaches. *International Journal of Instruction, 15*(1), 381–400. https://doi.org/10.29333/iji.2022.15122a

National Council of Teachers of Mathematics. (2023). *Principles to actions: Ensuring mathematical success for all*. National Council of Teachers of Mathematics. https://www.nctm.org/

OECD. (2023). *PISA 2022 results (Volume I): The state of learning and equity in education*. OECD Publishing. https://doi.org/10.1787/53f23881-en

Palinussa, A. L., Molle, J. S., & Gaspersz, M. (2021). Realistic mathematics education: Mathematical reasoning and communication skills in rural contexts. *International Journal of Evaluation and Research in Education, 10*(2), 522–534. https://doi.org/10.11591/ijere.v10i2.20640

Plomp, T. (2013). *Educational design research: An introduction*. Netherlands Institute for Curriculum Development (SLO).

Prahmana, R. C. I. (2022). Ethno-realistic mathematics education: The promising learning approach in the city of culture. *SN Social Sciences, 2*(12), Article 257. https://doi.org/10.1007/s43545-022-00571-w

Pratama, R. A., & Yelken, T. Y. (2024). Effectiveness of ethnomathematics-based learning on students' mathematical literacy: A meta-analysis study. *Discover Education, 3*(1), Article 202. https://doi.org/10.1007/s44217-024-00309-1

Purniati, T., Turmudi, T., Juandi, D., & Suhaedi, D. (2022). Ethnomathematics study: Learning geometry in mosque ornaments. *International Journal on Advanced Science, Engineering and Information Technology, 12*(5), 2096–2104. https://doi.org/10.18517/ijaseit.12.5.17063

Pusmenjar. (2023). *National assessment report 2023: Numeracy literacy achievement of Indonesian students*. Ministry of Education, Culture, Research, and Technology. https://pusmendik.kemdikbud.go.id/an/

Revina, S., & Leung, F. K. S. (2021). Issues involved in the adoption of realistic mathematics education in Indonesian culture. *Compare: A Journal of Comparative and International Education, 51*(5), 631–650. https://doi.org/10.1080/03057925.2019.1650636

Ritonga, S. I., Ramadhana, R. S. A., Dalimunthe, A. H., Latifah, N., Siregar, M. R. D., Rangkuti, R. K., & Harahap, H. M. (2025). The effectiveness of realistic mathematics learning based on Mandailing culture with a deep learning approach in improving logical thinking skills. *Riemann: Research of Mathematics and Mathematics Education, 7*(2), 111–120. https://doi.org/10.38114/reimann.v7i2.105

Rosa, M., & Orey, D. C. (2023). Ethnomathematics and culturally relevant mathematics education. *Journal of Mathematics and Culture, 17*(1), 1–15.

Sari, A. K., Budiarto, M. T., & Ekawati, R. (2022). Ethnomathematics study: Cultural values and geometric concepts in the traditional "Tanean-Lanjang" house in Madura-Indonesia. *JRAMathEdu, 7*(1), 46–54.

https://doi.org/10.23917/jramathedu.v7i1.15660

Sembiring, R. K., Hadi, S., & Dolk, M. (2008). Reforming mathematics learning in Indonesian classrooms through RME. *ZDM Mathematics Education, 40*(6), 927–939.

Sugiyono. (2019). *Metode penelitian kuantitatif, kualitatif, dan R&D* (2nd ed.). Alfabeta.

Sutarto, S., Muzaki, A., Hastuti, I. D., Fujiaturrahman, S., & Untu, Z. (2022). Development of an ethnomathematics-based e-module to improve students' metacognitive ability in 3D geometry topic. *International Journal of Interactive Mobile Technologies, 16*(3), 32–46. https://doi.org/10.3991/IJIM.V16I03.24949

Tong, D. H., Nguyen, T. T., Uyen, B. P., Ngan, L. K., Khanh, L. T., & Tinh, P. H. (2022). Realistic mathematics education's effect on students' performance and attitudes: A case of ellipse topics learning. *European Journal of Educational Research, 11*(1), 403–421. https://doi.org/10.12973/eu-jer.11.1.403

Utami, N. W., Sayuti, S. A., & Jailani, J. (2021). Indigenous artifacts from remote areas used to design a lesson plan for preservice math teachers regarding sustainable education. *Heliyon, 7*(3), e06417. https://doi.org/10.1016/j.heliyon.2021.e06417

Wibawa, F. S., Hariri, D. D., Mahmudah, H., & Kania, N. (2025). Bridging mathematics and culture: A systematic review of indigenous mathematical concepts in Indonesian traditions. *Contemporary Mathematics and Science Education, 6*(2), Article ep25013. https://doi.org/10.30935/conmaths/17076

Žakelj, A., & Vogrinc, J. (2022). The role of visual representations in geometry learning. *European Journal of Educational Research, 11*(1), 139–152. https://doi.org/10.12973/eu-jer.11.1.139