Kognitif
Jurnal Riset HOTS Pendidikan Matematika
Volume- 5 No- 4 Page 1653 – 1671
ISSN 2776-9704 P-ISSN 2776-9984
https://doi.org/10.51574/kognitif.v5i4.3860

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How to cite: Sam, F., Alam, S., & Patmaniar, P. (2025). Developing an Ethnomathematics-Based Transformational Geometry Textbook to Enhance Students' Mathematical Literacy. *Kognitif: Jurnal Riset HOTS Pendidikan Matematika*, *5*(4), 1653–1671. https://doi.org/10.51574/kognitif.v5i4.3860

To link to this artcle: https://doi.org/10.51574/kognitif.v5i4.3860

Kognitif: Jurnal Riset HOTS Pendidikan Matematika
https://doi.org/10.51574/kognitif.v5i4.3860 Volume 5, No 4, October - December 2025, pp. 1653– 1671

Developing an Ethnomathematics-Based Transformational Geometry Textbook to Enhance Students' Mathematical Literacy

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Article Info

Article history:

Received Sep 12, 2025
Accepted Nov 09, 2025
Published Online Dec 08, 2025

Keywords:

Development
Textbooks
Ethnomathematics
Math literacy
ADDIE

ABSTRACT

An ethnomathematical approach that integrates Luwu culture, especially the Rongkong batik motif, is expected to bridge abstract mathematical concepts with students' daily lives through the use of local wisdom as a learning context. This study aims to develop ethnomathematics-based transformational geometry textbooks that are feasible, practical, and effective in improving senior high school students' mathematical literacy. The research employed the ADDIE development model. The participants were Grade XI students and mathematics teachers at SMA Negeri 5 Luwu Utara. The instruments used included teacher and student needs analysis questionnaires, expert validation sheets, teacher and student practicality questionnaires, lesson implementation observation sheets, and a mathematical literacy test administered as a pretest and posttest. Validation by material and media experts was conducted to assess the feasibility of the textbook in terms of content, presentation, construction, and readability. The results show that the developed textbooks are classified as very feasible based on content, presentation, construction, and readability validation. The textbooks were also judged to be very practical by both teachers and students. In terms of effectiveness, there was a significant increase in students' mathematical literacy after using the textbooks, with an average n-gain of 0.81 (high category). Inferential analysis further indicated a significant difference between students' pretest and posttest scores. Thus, the ethnomathematics-based transformational geometry textbooks developed in this study are feasible for use in classroom instruction and effective in improving high school students' mathematical literacy. This study recommends local culture-based textbooks as an alternative form of contextual teaching materials with multicultural characteristics.

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Introduction

Mathematical literacy skills are a crucial competency for students in facing the demands of the 21st century. This ability includes not only understanding numbers, but also the application of mathematical concepts in real-life contexts (Susanta et al., 2023). However, the ability of individuals to formulate, apply, and interpret mathematics in various real-life contexts, as well as to use mathematical concepts, procedures, facts, and tools to solve problems, make decisions, and make judgments with a good mathematical understanding (Heyd-Metzuyanim et al., 2021). Mathematical literacy is not only related to the ability to calculate, but also involves the ability to think logically, analyze information, solve problems, and make data-driven decisions (Helgevold & Moen, 2015). Therefore, mathematics learning must be designed to not only teach concepts and formulas, but also to relate them to real-life situations that are relevant and meaningful to students (Kop et al., 2020). Thus, mathematical literacy not only improves academic competence, but also empowers students to become critical and capable individuals in the face of the challenges of modern life. However, the implementation of mathematical literacy faces a number of challenges, especially in ensuring that the learning process is in accordance with local needs and contexts. One of the main challenges is the lack of textbooks that integrate local cultural content in the subject matter, especially in areas with unique cultural richness (Kop et al., 2017).

The results of national assessments and international studies such as PISA show that students' mathematical literacy skills in Indonesia are still relatively low (Habibi & Suparman, 2020; Kanes et al., 2014; OECD, 2018; Zulkardi et al., 2020). The results of interviews with mathematics teachers about the education report card at UPT SMN 5 North Luwu in 2023 show that students' mathematical literacy ability has reached 28.89% who have reached the minimum competence, meaning that the mathematics literacy ability at UPT SMN 5 Luwu Utara is in the poor category. This happens because students do not understand the problem. The use of textbooks that are in accordance with local culture is still very minimal, most of them ignore the elements of local wisdom, especially at SMAN 5 Luwu Utara. Whereas by integrating local culture into textbooks, students will find it easier to understand and relate the material to their own experiences, thereby increasing student engagement and motivation in learning (Ninsiana, 2018). This indicates the need for innovation in mathematics learning, one of which is by innovating textbook design that is relevant to the local cultural context.

One of the approaches in mathematics learning that relates the concept of mathematics to the culture, traditions, and wisdom of the local community is ethnomathematics (Apolonia Hendrice Ramda et al., 2023; Muhtadi et al., 2017; Prahmana et al., 2021). Linguistically, ethnomathematics comes from the word "*ethno*" which means something that refers to the socio-cultural context, "*mathema*" means explaining, knowing, and doing activities, and "*tics*" comes from the word *techneyang* which means technique (Prahmana & D'Ambrosio, 2020). Ethnomathematics is also defined as mathematical activities that involve numbers, patterns, and other mathematical concepts that are rooted in the local culture of the community (Charitas et al., 2023). In simple terms, ethnomathematics is a science that studies the relationship between mathematics and culture (Muhtadi et al., 2017). By integrating the cultural values that exist in the student environment, ethnomathematics not only enriches the understanding of mathematical concepts contextually, but can also foster a sense of pride and appreciation for one's own cultural heritage. However, until now, the existence of mathematics textbooks that integrate the concept of geometric transformation with the local cultural context is still very limited. Thus, this research aims to develop ethnomathematics-based geometry transformation textbooks that are feasible, practical, and effective in improving the mathematical literacy of high school students.

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https://doi.org/10.51574/kognitif.v5i4.3860 Volume 5, No 4, October - December 2025, pp. 1653– 1671

Method

Types of Research

This research uses *Research and Development (R&D)* which aims to produce textbooks on geometry transformation with the context of local culture through the development process. The use of *Research and Development (R&D)* allows this research not only to produce innovative geometry transformation textbooks, but also to ensure that the geometry transformation textbooks are valid, practical, and effective to be applied in the context of learning. This research is designed to create an ethnomathematics-based geometry transformation textbook that is relevant to the cultural context of Luwu to improve students' mathematical literacy by using the ADDIE model which consists of five stages, namely *analysis*, *design*, *development*, *implementation*, and *evaluation***.** The stage of the ADDIE development model can be seen in the following Figure 1

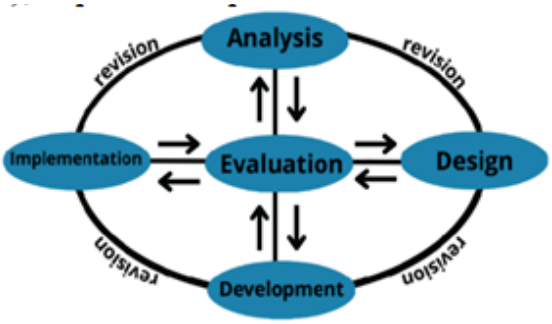

Figure 1. ADDIE development model stage

This model was chosen because the ADDIE development model framework provides a systematic approach in designing and developing textbooks. ADDIE's development model is particularly relevant to educational research because it provides a clear structure for developing, implementing, and evaluating the resulting products. The development of Ethnomathematics-based Geometry Transformation Textbooks not only focuses on improving students' mathematical literacy skills, but also is an effort to develop textbooks that are in accordance with Luwu's local culture by integrating elements of local wisdom.

Research Subject

The subject of this study is 30 students in grade XI.5 of SMA Negeri 5 Luwu Utara. The selection of students as subjects aims to determine the level of understanding, attractiveness, and effectiveness of ethnomathematics-based geometry transformation textbooks on improving their mathematical literacy .

Instruments

The instruments used in the process of developing ethnomathematics-based geometry transformation textbooks include questionnaires, validation sheets, learning implementation sheets, and tests. The questionnaires used consisted of a teacher needs analysis questionnaire, a student needs analysis questionnaire, and a practicality questionnaire. The teacher needs analysis questionnaire is an initial instrument to identify the views and needs of educators in mathematics learning that is integrated with the local cultural context. The student needs analysis questionnaire is an instrument that provides a more complete picture of their learning

experience, both in terms of understanding the material, interest in contextual approaches, and the obstacles they face so that the data obtained becomes the basis for compiling textbooks that are in accordance with the characteristics and needs of students in the North Luwu area. The practicality questionnaire consists of a questionnaire of teacher and student responses to the developed textbook.

The validation sheet was used to assess ethnomathematics-based geometry transformation textbooks developed to improve the mathematical literacy of high school students in the North Luwu area. Validation was carried out by material experts and media experts using four main aspects of assessment, namely content feasibility, presentation, construction, and readability. The learning implementation sheet is an instrument used to assess the extent to which the learning process in the classroom runs in accordance with the planning that has been prepared in the ethnomathematics-based geometry transformation textbook. This instrument functions as an observation tool to monitor the implementation of learning by teachers and student participation when the textbook is applied. The assessment is carried out by observers who directly observe teaching and learning activities in the classroom, so that the data obtained is objective and can be used as evaluation material.

The mathematics literacy ability test is used as a measuring tool to determine the effectiveness of ethnomathematics-based geometry transformation textbooks in improving the understanding and mathematical literacy skills of high school students. The test is contextually designed by taking into account the characteristics of the local culture of North Luwu which are integrated into the math problems. The preparation of questions not only emphasizes the aspect of mastery of concepts, but also on students' ability to apply mathematics in daily life, analyze number-based information, and make relevant data-based decisions. The test instruments include *a pretest* and *posttest* designed to measure students' mathematical literacy skills before and after the use of textbooks. The results of the test also became the basis for evaluating the extent to which the textbooks developed were able to encourage students to think logically, reason mathematically, and relate mathematics to culture and real life. Thus, the mathematical literacy ability test serves as an important instrument in measuring the direct impact of the application of contextual textbooks in the learning process.

Research Stages

The research stage is the steps taken in the process of developing an Ethnomathematics-based Geometry Transformation Textbook. The development process of the Ethnomathematics-based Geometry Transformation Textbook with ADDIE consists of 5 stages. In the *analysis* stage, the needs of students and teachers will be identified in the context of ethnomathematics-based mathematics literacy learning and the identification of Luwu's local cultural potential that can be integrated into textbooks. At the *design* stage, an ethnomathematics-based Geometry Transformation Textbook will be designed with the structure and content of the textbook that integrates Luwu's local culture with Geometry Transformation material. At the *development stage*, the Ethnomathematics-based Geometry Transformation Textbook will be validated related to content, images, materials, and assessments. The results of the validation are input in improving the Ethnomathematics-based Geometry Transformation Textbook. Furthermore, a trial will be carried out on the application of Ethnomathematics-based Geometry Transformation Textbooks in mathematics learning At *the implementation* stage, the application of Ethnomathematics-based Geometry Transformation Textbooks will be carried out in mathematics learning. At the *evaluation stage, it* will be carried out to assess the validity, practicality, and effectiveness of the Ethnomathematics-based Geometry Transformation Textbook.

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Data Analysis

The data analysis technique used in this study uses a qualitative and quantitative descriptive approach. Qualitative data were obtained from the results of observations during the implementation of the Ethnomathematics-based Geometry Transformation Textbook in learning. Quantitative data was obtained from the results of expert validation (content, images, materials, and assessments), pretest results, posttest results, and results from the questionnaire given. The conclusion was drawn based on the results of measuring the validity, practicality, and effectiveness of the Ethnomathematics-based Geometry Transformation Textbook. The validity of the textbook is measured based on the assessment of expert validators. The validator assigns a score on each aspect that is assessed and calculated using the following formula:

$$\text{Percentage} = \frac{\text{Number of scores awarded by validators}}{\text{Maximum score amount}} \times 100\%$$

If the result of the percentage of validity obtained is at least 0.40 with sufficient criteria, then the product is declared valid based on categorization (Nisrina et al., 2022) in the following Table 1

Table 1. Product validity criteria

Result	Criterion
$0.80 < V \leq 1.00$	Very high
$0.60 < V \leq 0.80$	Tall
$0.40 < V \leq 0.60$	Keep
$0.20 < V \leq 0.40$	Low
$0.00 < V \leq 0.20$	Very low
$V < 0.00$	Invalid

The practicality of the textbook is measured based on the results of the questionnaire given to teachers and students after implementing the Ethnomathematics-based Geometry Transformation Textbook in learning. The scores obtained from the questionnaire were analyzed using the following formula.

$$\text{Percentage} = \frac{\text{Total scores obtained}}{\text{Maximum score amount}} \text{ x } 100\%$$

If the percentage of practicality exceeds 60%, then the product is declared practical and suitable for use based on the categorization in the following Table 2

Table 2. Product practicality criteria

Category	Rating (%)
Very practical	$80 < P \leq 100$
Practical	$60 < P \leq 80$
Quite practical	$40 < P \leq 60$
Less practical	$20 < P \leq 40$
Impractical	$0 < P \leq 20$

Research Findings

Analysis Stage

This stage aims to identify actual problems and needs in the field, both from the perspective of teachers as learning facilitators and students as the main subjects in the learning process. This needs analysis is an important foundation in the preparation of textbooks that are contextual, applicative, and in accordance with the characteristics of students and the conditions of the local cultural environment, in this case the culture in North Luwu Regency. The results of the analysis of teacher needs, it can be interpreted that in general there is *very high support* from teachers for the development of ethnomathematics-based geometry transformation textbooks in mathematics learning in schools. The average percentage of statements reached 97.22%, which reflects the level of need, awareness, and enthusiasm of teachers in associating mathematics learning with the local cultural context, especially to improve students' mathematical literacy. The results of the analysis of student needs showed a very high positive response rate with an average of 95.3%, there are a number of important implications for the development of ethnomathematics-based geometry transformation textbooks to improve the mathematical literacy of high school students, especially in North Luwu. The data indicate that students are eager to learn mathematics that is associated with everyday life and local culture, as well as want to understand how mathematical concepts are used in their own cultures.

Design Stage

This stage includes planning the structure of the textbook, the selection of local cultural content, mapping learning outcomes, learning objectives (ATP), and designing learning activities based on the local context. The textbook design is focused on the integration of mathematical literacy through contextual activities that reflect the local cultural values of North Luwu Regency, namely in *Rongkong* batik. The following is the design of *the Rongkong* batik motif which is included in the Ethnomathematics-based Geometry Transformation Textbook.

Development Stage

At this stage, the preparation and production of textbooks is carried out comprehensively based on the results of previous analysis and design, including the selection of local cultural content, textbook structure, and contextual mathematical literacy approaches. After the product is developed, the next step is the validation process by experts as a form of initial testing of the quality of the textbook. This validation includes four main aspects, namely content feasibility, presentation, construction, and readability. The following is presented the results of the validation of textbook development on the feasibility aspect of content.

Table 3. Summary of the results of textbook development validators on the feasibility aspect of content

Yes	Assessment Criteria	Pi(%)	Ket.
1	Suitability of the material with basic competencies and learning objectives	80	Proper
2	Truth of the concept/material presented	100	Highly Worth It
3	Suitability of the material with the relevant ethnomathematical context	100	Highly Worth It
4	The depth and breadth of the material according to the high school level	90	Highly Worth It
5	Textbooks are able to stimulate students' mathematical literacy	90	Highly Worth It
6	Relevance of materials to the needs and characteristics of learners	90	Highly Worth It
7	Illustrations/images/visuals support concept understanding	90	Highly Worth It
	Average	91.43	Highly Worth It

Source: results of primary data analysis (2025)

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The feasibility aspect of the content, which includes the suitability of the material with the basic competencies and learning objectives, the correctness of the mathematical concepts presented, the relevance of the material to the ethnomathematical context, and the ability of textbooks to stimulate students' mathematical literacy. With an average score of 91.43%, this textbook is included in the Very Decent category in terms of content. This means that the content of the textbook has met the pedagogical principles and academic substance needed in ethnomathematics-based mathematics learning at the high school level. This textbook can be used in learning with little or even no revision to the content aspect, so it has great potential to support the strengthening of students' mathematical literacy through a contextual and meaningful approach.

Furthermore, after obtaining excellent results on the feasibility aspect of the content, an analysis was also carried out on the aspect of presentation to assess how the material was arranged and delivered in the textbook. This aspect is important because a systematic, engaging, and interactive presentation will greatly affect student engagement in the learning process. Good presentation not only supports concept understanding, but also strengthens the effectiveness of textbooks in achieving learning goals, especially in the context of strengthening mathematical literacy through ethnomathematical approaches. The following are presented the results of the validation of textbook development in the presentation aspect.

Table 4. Summary of the results of the textbook development validator on the presentation aspect

Yes	Assessment Criteria	Pi(%)	Ket.
1	Systematic and logical presentation of material	80	Highly Implemented
2	Consistent and easy-to-follow textbook structure	100	Highly Worth It
3	Attractive and appropriate format and layout	90	Highly Worth It
4	There are activities/questions that hone math literacy	80	Highly Implemented
5	Interactive materials and encourage active student participation	80	Highly Implemented
6	Instructions for using the textbook are clear and easy to understand	100	Highly Worth It
7	Use of appropriate and communicative language	90	Highly Worth It
8	Illustrations/images/visuals support concept understanding	90	Highly Worth It
	Average	88.75	Highly Worth It

The aspect of presentation, assessing how the material is arranged in a systematic, logical, and interesting manner. The components assessed include a consistent presentation structure, clarity of instructions for use, the existence of activities or questions that actively involve students, and the integration of text, illustrations, and other visual elements. Good presentation will make it easier for students to understand the material and encourage their involvement in the learning process. The validation results on the presentation aspect showed that this ethnomathematics-based geometry transformation textbook was in the very feasible category, with an average score of 88.75%. The presentation aspect includes how the material is arranged, displayed, and delivered visually and textually in the textbook. In line with the findings on the presentation aspect, the assessment of the construction aspect is also an important part in assessing the overall quality of the textbooks developed. The following is presented the results of the validation of textbook development on the construction aspect.

Table 5. Summary of the results of validators for textbook development on construction aspects

Yes	Assessment Criteria	Pi(%)	Ket.
1	Consistent and easy-to-follow textbook structure	90	Highly Worth It
2	Page numbering is clear and consistent	100	Highly Worth It
3	Visual design of attractive and consistent materials	90	Highly Worth It
4	Consistent use of color throughout the material	90	Highly Worth It
5	Consistent typeface and font size	100	Highly Worth It
6	Illustrations and images are used consistently in style and quality	80	Proper
7	Consistent page format (spaces, margins, fonts)	100	Highly Worth It
	Average	92.86	Highly Worth It

Source: results of primary data analysis (2025)

The construction aspect, focusing on technical quality and textbook design. This includes the consistency of formatting, page numbering, typeface and font size, and the suitability of illustrations and images with the content of the material. An attractive and consistent visual design can improve reading comfort and strengthen conceptual understanding. The results of the validation of the construction aspect showed that the ethnomathematics-based geometry transformation textbook was in the very feasible category, with an average score of 92.86%. Assessments on this aspect reflect the technical and aesthetic qualities of the textbook, which include regularity, consistency, and ease of use. As a complement to the construction aspect, readability is an important element that also determines the effectiveness of textbooks in conveying information clearly and easily understood by students. The following is presented the results of the validation of textbook development on the readability aspect.

Table 6. Summary of results Validator Textbook Development on Readability Aspect

Yes	Assessment Criteria	Pi(%)	Ket.
1	The language used is according to the target audience (high school students)	80	Proper
2	Consistent writing style throughout the textbook	90	Highly Worth It
3	Technical terms clearly defined	80	Proper
4	Effective sentence structure and according to the student's cognitive level	80	Proper
5	Text can be easily understood by high school students	100	Highly Worth It
6	The title of the textbook is clear and relevant to the content	100	Highly Worth It
7	The foreword provides an overview of the material and learning objectives	90	Highly Worth It
8	Table of contents makes it easy to find information	100	Highly Worth It
9	Glossary helps with understanding important terms	90	Highly Worth It
	Average	90	Highly Worth It

The readability aspect, assessing the extent to which the language used in the textbook is in accordance with the cognitive level of high school students. Communicative language, effective sentence structure, and clear explanations of technical terms are indicators of good readability. High readability will make it easier for students to understand the content of the textbook independently. The results of the validation of the readability aspect showed that ethnomathematics-based geometry transformation textbooks were in the very feasible category, with an average score of 90%. This aspect of readability reflects the extent to which the language, sentence structure, and presentation of text in textbooks can be understood by high school students as target users.

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Implementation Stage

After the ethnomathematics-based geometry transformation textbook is declared valid by experts, the next step is the implementation stage, which is a limited trial in the classroom environment. This stage aims to see the extent to which the developed textbooks can be applied practically and effectively in real learning situations. This implementation process involves observation of the implementation of learning carried out by *observers*, as well as data collection through practicality questionnaires given to teachers and students. This questionnaire was used to find out their responses to the ease of use, relevance of the content, and the attractiveness of the textbooks used. Responses from teachers are one of the important indicators in assessing the success and functionality of textbooks practically. With an average practicality score of 90.63%, this ethnomathematics-based geometry transformation textbook is generally included in the "Very Practical" category and has great potential to be widely used in contextual, meaningful, and culture-based mathematics learning. However, the aspect of ease for teachers in learning students still needs to be improved, because they obtain lower scores compared to other indicators. Therefore, further development is recommended, such as improving the use and training guidelines for teachers so that they can make optimal use of this textbook in the classroom. Student responses also showed that the presentation of textbooks was interesting (99.17%), the use of language was easy to understand (100%), and the worksheets were in accordance with students' understanding (97.5%). This indicates that the textbook has been designed well from a pedagogical and aesthetic point of view, thus supporting student involvement in the learning process. In fact, material related to Luwu culture was considered very useful by students (94.17%).

Overall, these data indicate that ethnomathematics-based geometry transformation textbooks are very effective in creating fun, meaningful, and contextual mathematics learning. In addition to improving understanding of concepts, textbooks also reinforce local cultural values and motivate students to learn more actively. With a very high average response across all indicators, it can be concluded that this textbook has great potential for widespread use, especially in an effort to integrate mathematics education with local wisdom and a more humanistic approach to learning.

In general, the implementation of learning can be said to be very effective, shown by the dominance of the "Very Implemented" score in almost all aspects. However, these results also provide input that the use of varied learning methods as well as the implementation of reflective activities and reinforcement of concepts at the end of learning need to be further optimized. Improvement efforts in this area will further improve the implementation of ethnomathematics textbooks in the context of meaningful and contextual learning.

Evaluation Stage

In this study, evaluation was carried out through the provision *of pretest* and *posttest* of mathematical literacy to students before and after the use of textbooks. The purpose of this test is to measure the extent to which students' mathematical literacy understanding and skills develop after participating in local cultural context-based learning. The results of this evaluation were then analyzed descriptively to see the distribution of scores and the tendency to improve students' abilities. The data of *the students' pretest* and *posttest* results are presented in the form of frequency distribution with the aim of making it easier for readers to understand and interpret the distribution of scores obtained by students before and after learning using ethnomathematics-based geometry transformation textbooks. Presentation in the form of frequency distribution allows for a more structured analysis of data patterns, such as the number

of students in a certain score range, the concentration of scores in certain categories, and the shift in score distribution from *pretest* to *posttest*.

By displaying the data in the form of a frequency distribution, the comparison between the initial and final conditions can be observed visually and numerically. This helps in assessing the level of improvement in students' mathematical literacy skills, as well as providing a clearer picture of the effectiveness of the textbooks developed. In addition, this form of presentation facilitates the process of data categorization, advanced descriptive analysis, and the preparation of graphs, such as histograms or bar charts, which can strengthen the overall interpretation of research results. For more details, the following is presented the distribution *of the frequency of pretest* and posttest students' mathematical literacy abilities into categorization with an interval of 10 in the Table 7

Table 7. Distribution of *pretest* and *posttest frequencies of* students' mathematical literacy ability

Score Interval	Category	*Pretest*		*Posttest*	
		Frequency	**%**	**Frequency**	**%**
91 – 100	Very Good	0	0	10	33.33
81 – 90	Excellent	0	0	20	66.67
71 – 80	Good	0	0	0	0
61 – 70	Pretty Good	2	6.67	0	0
51 – 60	Enough	14	46.67	0	0
41 – 50	Less	14	46.67	0	0
31 – 40	Less Than Once	0	0	0	0
21 – 30	Very Less	0	0	0	0
11 – 20	Very Low	0	0	0	0
0 – 10	Unable to Afford	0	0	0	0
	Sum	30	100	30	100

Based on the Table 7, there appears to be a very significant change in the frequency distribution of scores between the results *of the pretest* and *posttest of* students' mathematical literacy skills after the use of ethnomathematics-based geometry transformation textbooks. At the time of *the pretest*, the majority of students were in the categories of "Sufficient" (51–60) and "Less" (41–50), each as many as 14 students or 46.67%. Meanwhile, only 2 students (6.67%) were in the "Fairly Good" category (61–70), and none of the students reached the "Good", "Very Good", or "Very Good" category. This shows that before learning using ethnomathematics-based geometry transformation textbooks, students' mathematical literacy skills in general were still at low to medium levels, without any students showing high achievement. In contrast, the posttest results showed a very drastic shift in the distribution of scores to the top category, with not a single student falling below the "Excellent" category. A total of 20 students (66.67%) were in the "Very Good" category (81–90) and 10 students (33.33%) even reached the "Very Good" category (91-100). No students are in the "Good" category or below, which indicates that all students have improved their overall abilities.

The shift in the distribution of grades from the low category (at the *time of the pretest*) to the very high category (at the time *of the posttest*) indicates that learning using ethnomathematics-based geometry transformation textbooks has very high effectiveness in improving students' mathematical literacy skills. The textbook is suspected to be able to bridge the understanding of the concept of mathematical literacy through a contextual approach based on local culture (in this case, Rongkong culture), thereby helping students in understanding, reasoning, and applying mathematical concepts in real life. With the absence of students in the low category during *the posttest*, and all students in the "Very Good" and "Very Good" categories, it can be concluded that the use of ethnomathematics-based geometry

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transformation textbooks significantly improves the mathematical literacy ability of high school students, both in terms of individual achievement and the collective distribution of the class.

After it is known that there is a difference between students' pretest and posttest scores, a gain analysis is then carried out to find out the extent of the improvement of students' mathematical literacy skills after participating in learning using ethnomathematics-based geometry transformation textbooks. Gain analysis is carried out by calculating the difference between posttest and pretest scores, then comparing them to the maximum score that can be achieved, to determine the relative effectiveness of learning improvement.

The use of gain analysis aims to provide a more concrete picture of the extent of the improvement in ability experienced by students individually and in groups, not only statistically, but also practically. In this context, the gain score can be classified into effectiveness categories, such as high, medium, or low, according to the criteria developed by Hake (1998), namely: high gain ($g \geq 0.7$), moderate gain ($0.3 \leq g < 0.7$), and low gain ($g < 0.3$).

Through gain analysis, additional information can be obtained that strengthens the conclusion that the development of ethnomathematics-based geometry transformation textbooks is not only statistically significant, but also effective in substantially improving the mathematical literacy of high school students. This analysis is also useful for identifying individual student success rates, as well as being a basis for consideration for further textbook development or implementation on a broader scale. For this reason, the following is presented a gain analysis in the Table 8.

Table 8. Summary of the results of the analysis of students' mathematical literacy ability gain

Interval	Category	Frequency	%
$g \geq 0.7$	Tall	30	100
$0.3 \leq g < 0.7$	Keep	0	0
$g < 0.3$	Low	0	0
Sum		30	100
Average gain		0,81	

Source: results of primary data analysis (2025)

Based on the results of the gain analysis on the pretest and posttest scores of students' mathematical literacy ability, it was found that all students (100%) were in the high gain category ($g \geq 0.7$), with an average gain score of 0.81. None of the students were included in the medium gain ($0.3 \leq g < 0.7$) or low gain ($g < 0.3$) category. This shows that all students experience a very significant and effective increase in mathematical literacy skills after participating in learning using ethnomathematics-based geometry transformation textbooks.

The average gain value of 0.81 is included in the high category, based on the classification of the effectiveness of learning improvement proposed by Hake (1998), which states that a gain value of ≥ 0.7 indicates very high learning effectiveness. In other words, the textbooks developed not only produce statistically significant differences in pretest and posttest scores but are also practically able to improve student learning outcomes optimally.

These findings reinforce the results of the previous frequency distribution, where all students experienced an increase from the low category to the very good and very good category. This reflects that the integration of the local cultural context of Rongkong into mathematics learning through an ethnomathematical approach not only increases student engagement, but also makes a real contribution to improving mathematical literacy competencies in the context of daily life. Therefore, gain analysis is strong evidence that the development of ethnomathematics-based geometry transformation textbooks is effective in improving the mathematical literacy of high school students, both quantitatively and qualitatively

In addition, hypothesis testing was also carried out to statistically test whether the difference in results between the pretest and posttest was significant, so that it can be concluded that the textbooks developed really have a positive impact on students' mathematical literacy. To test this hypothesis, *pretest* and *posttest data* collected from students in the experimental class were used. Before testing hypotheses on improving students' mathematical literacy skills, an important step that needs to be taken is to test the prerequisites for statistical analysis. This prerequisite test aims to determine the appropriate and valid type of statistical test, as well as ensure that the data meets the basic assumptions required by the analysis techniques to be used.

In this study, the data analyzed came from two groups of paired scores, namely *pretest* and *posttest scores* from the same students. Because the initial plan for testing the hypothesis uses a parametric statistical technique, namely *the Paired Sample t-Test*, it is necessary to carry out a prerequisite test for normality of data distribution.

The normality test aims to find out whether the data on the difference in pretest and posttest scores is distributed normally. If the data is normally distributed, then hypothesis testing can be performed using a parametric test (*Paired Sample t-Test*). However, if it is not normal, then *a non-parametric* test that does not require a specific distribution, such as *the Wilcoxon Signed-Rank Test*, is used. The following is presented the results of the analysis of the normality test of mathematical literacy ability data for the three methods in the following Table 9

Table 9. Summary of the analysis of the normality test of mathematical literacy ability data

Normality Test	Statistics	*p-value*	Interpretation
Shapiro-Wilk	0,896	0,007	Abnormal (due to $p < 0.05$)
Kolmogorov-Smirnov	0,233	0,076	Normal ($p > 0.05$)
Anderson-Darling	1,36	0,001	Abnormal ($p < 0.05$)

Source: Primary data analysis results (2025)

The results of data processing carried out on the mathematics literacy ability score of SMA 5 North Luwu students after using ethnomathematics-based geometry transformation textbooks, normality tests were carried out to determine the right type of statistical test in testing the hypothesis of increasing this ability. The normality test was carried out using three methods, namely Shapiro-Wilk, Kolmogorov-Smirnov, and Anderson-Darling. The results of the Shapiro-Wilk test showed a statistical value of 0.896 with a significance value (*p-value*) of 0.007. This p-value is smaller than the set significance level, which is 0.05, so it can be concluded that the data is not normally distributed. Furthermore, the Anderson-Darling test yielded a statistical value of 1.36 with *a p-value* of 0.001, which also indicates that the data is not normally distributed. Although the results of the Kolmogorov-Smirnov test showed *a p-value* of 0.076 (greater than 0.05) which technically indicates a normal distribution, this test tends to be less sensitive to the distribution of data in small to medium-sized samples. Therefore, the results of the more sensitive Shapiro-Wilk and Anderson-Darling tests are considered more representative in determining the distribution of data.

Overall, the results of the normality test can be concluded that the data on students' mathematical literacy ability scores after treatment are not distributed normally. The implication of these findings is the selection of the appropriate type of hypothesis test. Because the data do not meet the assumption of normality, parametric tests such as *paired sample t-tests* cannot be used validly. Therefore, to test whether there is a significant improvement between students′ *pretest* and *posttest* scores after using ethnomathematics-based geometry transformation textbooks, a more precise *non-parametric* test, namely the Wilcoxon Signed-Rank Test, is used. This test does not assume a normal distribution and is more suitable for

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dependent samples such as *pretest* and *posttest*. Thus, the selection of statistical approaches in this study still maintains the validity and reliability of the analysis results on improving the mathematical literacy skills of SMA5 students of North Luwu. The following is a summary of the analysis of the presentation of the hypothesis which can be seen in the following table.

Table 10. Wilcoxon *signed-rank test* results between *pretest* and *posttest scores*

Test statistics	Value	*p-value*	*Effect size*
Wilcoxon W	<0.001	<0.001	-1,00

Source: Primary data analysis results (2025)

The test results showed that the Wilcoxon statistical value (W) was less than 0.001 with a significance *value (p-value*) of < 0.001. This value is far below the set significance level (α = 0.05), so it can be concluded that there is a very significant difference between the *pretest* and *posttest* scores of students after participating in learning with ethnomathematics-based geometry transformation textbooks. A very low W value indicates that almost all students have an increase in score, or that the entire *posttest* score is higher than *the pretest*. The *effect size value*, which is -1.00, shows that the effect of the treatment is relatively strong. A negative sign indicates the direction of the difference (*pretest* < *posttest*), not a negative effect. Thus, the results of *the Wilcoxon Signed-Rank Test* (W = <0.001; p <0.001; r = -1.00), concluded that the zero hypothesis (H0) states that there is no improvement in students' mathematical literacy ability, and the alternative hypothesis (H1) states that there is an increase in acceptability ability. This increase is not only statistically significant, but also reflects the positive influence of the integration of local culture into math learning. The ethnomathematics-based geometry transformation textbook can connect mathematical concepts with a cultural context that is close to the lives of students, in this case the local culture of Rongkong. This makes learning more meaningful and relevant and encourages students to understand and apply the concept of mathematical literacy in various contextual situations more actively. These findings are in line with an ethnomathematical approach that emphasizes that mathematics is not just a collection of formulas, but also part of society's social and cultural practices.

Discussion

Validity of Ethnomathematics-based Geometry Transformation Textbook

The very high validity of the textbook shows that ethnomathematics can be translated into a structured and curriculum-aligned learning resource, not only a conceptual idea. The four validated aspects, namely content, presentation, construction, and readability, indicate that the integration of Rongkong culture does not reduce conceptual precision, but instead supports it. This addresses a common concern that cultural elements may only appear as decoration and do not touch the core of the mathematical ideas. In this textbook, cultural motifs such as batik patterns and local architectural forms become concrete entry points to formal concepts of transformation, symmetry, and spatial structure (Muhtadi et al., 2017; Prahmana et al., 2021). This is consistent with D'Ambrosio's view that mathematics grows and takes meaning within cultural practices, not outside them. In the context of mathematical literacy, such design helps students move from "seeing culture" to "reasoning mathematically through culture," which is a deeper level of contextualization (Prahmana & D'Ambrosio, 2020).

The alignment with national curriculum standards and BSNP criteria shows that ethnomathematics does not stand in opposition to formal standards. Instead, it offers an alternative pathway to meet the same standards through contexts that are closer to students' lives (Voigt et al., 2020). Content validity here means more than "no conceptual errors." It includes the selection of problems that mirror real decision-making situations, patterns, and

quantitative reasoning that students may meet in their environment. When students work with transformations of Rongkong batik motifs, they implicitly train skills required in mathematical literacy, such as interpreting visual information, identifying regularities, and representing relationships symbolically (Marufi et al., 2021). Thus, the high validity score can be interpreted as evidence that the textbook successfully connects three layers at once: cultural meaning, school curriculum, and the broader construct of mathematical literacy promoted in national assessment policies.

From a design perspective, the strong scores on presentation, construction, and readability indicate that ethnomathematical content has been organized in a way that supports cognitive processing. Layout, sequencing of tasks, and clarity of language reduce extraneous cognitive load, so students can focus on the core mathematical ideas embedded in cultural contexts. This matches Mayer's multimedia principles, where well-chosen images and texts work together rather than compete for attention. In this textbook, local images are not merely illustrations placed on the margins. They are part of the reasoning process that students need to follow, for example when they analyze symmetry in batik or transformations in traditional house structures (Pathuddin et al., 2021; Utami et al., 2019). This suggests that validity in ethnomathematics-based materials must be understood as both epistemic (truth and consistency of content) and semiotic (how representations support meaning-making).

Practicality of the Ethnomathematics-Based Geometry Transformation Textbook

The very high practicality ratings from teachers show that the textbook fits real classroom constraints and teaching routines. This is important because many innovative materials fail not at the level of ideas, but at the level of day-to-day usability. Teachers' positive responses indicate that they do not view the integration of local culture as an additional burden, but as a help to explain abstract topics such as transformation (Ninsiana, 2018). In practice, teachers can use a single resource to meet several goals at once: covering the geometry transformation curriculum, supporting mathematical literacy, and responding to Merdeka Curriculum demands for contextual and local-culture-based learning (Charitas et al., 2023; Evin Gencel & Saracaloğlu, 2018). This convergence of purposes increases the likelihood that the textbook will be used sustainably, not just as a one-time project.

From the perspective of culturally responsive teaching, teacher acceptance also reflects a shift in professional identity. Teachers no longer see themselves only as transmitters of universal mathematical knowledge, but as mediators between global mathematics and local cultural wisdom (Abdullah, 2017). The textbook provides concrete models and language to support this mediation, which is often difficult if left entirely to teacher improvisation. However, the very high practicality scores should also be read critically. They may hide variation in teachers' depth of understanding of ethnomathematics concepts, or differences in how intensively cultural discussions are carried out in class (Prahmana et al., 2021). Future classroom observations and teacher interviews are needed to see whether teachers only "use" the textbook or also "reinterpret" it creatively according to their students' contexts.

Students' very positive responses complement the teachers' views and strengthen the claim of practicality. For students, practicality means that the textbook is easy to follow, interesting, and does not create unnecessary confusion when they work individually or in groups. High practicality suggests that students can navigate between cultural narratives, visual representations, and symbolic mathematical work without feeling lost (Tondorf & Prediger, 2022; Wilkie & Hopkins, 2024). In terms of mathematical literacy, this is important because literacy tasks almost always demand movement between different forms of representation and contexts (Helgevold & Moen, 2015; Susanta et al., 2023). The Rongkong-based tasks invite

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students to talk, draw, estimate, and calculate in one integrated activity. This kind of engagement is difficult to achieve if the textbook is not perceived as "friendly" and manageable by the students themselves.

Effectiveness of the Ethnomathematics-Based Geometry Transformation Textbook

The high effectiveness of the textbook, as indicated by the gain and hypothesis test results, needs to be interpreted in relation to how the tasks are structured. Mathematical literacy does not only concern mastering formulas for transformations, but also using those concepts to interpret and solve real problems (Heyd-Metzuyanim et al., 2021). The contextual tasks in this textbook require students to read visual information, identify patterns, choose appropriate mathematical models, and justify their answers. When students analyze Rongkong batik motifs to reason about symmetry or transformations, they work through a literacy chain: from observing, to representing, to operating, to interpreting. The improvement in scores suggests that many students moved along this chain more successfully after learning with the textbook compared to before.

The ethnomathematical approach also appears to influence how students see the relevance of mathematics. When tasks relate to forms, symbols, and practices they already know, students are more likely to treat mathematics as a tool for understanding their world rather than as a separate school subject (Gulkilik et al., 2020; Montenegro et al., 2018). This shift in perception can help explain why literacy gains are high, not only because students "practice more questions," but because they commit more cognitive and emotional resources to the tasks. The Rongkong context acts as a cognitive scaffold that supports inference and problem-solving. Students do not start from zero; they start from patterns they already recognize, then move toward formal mathematical descriptions. In terms of Vygotsky's theory, culture here functions as a mediating tool that guides students through their zone of proximal development in mathematical literacy.

The effectiveness indicators also show that local culture can be a powerful medium to meet national and international expectations about mathematics learning. Definitions of mathematical literacy in PISA or national assessments emphasize the ability to use mathematics in varied life contexts. The textbook demonstrates that "life contexts" do not need to come from generic or Western situations (Habibi & Suparman, 2020; Tohir, 2019). They can come from indigenous motifs, local architecture, or community practices if tasks are carefully designed. This has important implications for regions with strong cultural identities. Rather than importing all contexts from outside, schools can build literacy through local realities while still meeting global benchmarks. In this sense, the textbook contributes to decolonizing mathematics learning without reducing academic rigor.

At the same time, the effectiveness findings must be read with methodological caution. The study took place in one school and one region, with a specific cultural background and teacher team. It is possible that the strong gains are partly supported by teacher enthusiasm, novelty effects, or local conditions that are not easily replicated elsewhere (Charitas et al., 2023; Supiyati et al., 2019). The statistical evidence shows real improvement, but it does not yet answer questions about how durable the learning is over time or how well students transfer these literacy skills to other mathematical topics. Future research needs to include delayed post-tests, cross-school comparisons, and qualitative analyses of students' solution strategies to understand which components of the textbook contribute most to learning.

Beyond the numeric indicators, the effectiveness of the textbook can also be seen in its potential to shape students' identities. When students see their culture presented as a legitimate source of mathematical ideas, they receive an implicit message that their background is valuable

and intellectually rich (Freeman et al., 2020). This can counter the perception that mathematics belongs only to "modern" or "foreign" worlds. Identity affirmation is not directly captured in literacy scores, but it can influence long-term engagement with mathematics, choice of further studies, and willingness to participate in mathematically laden decisions in society. Thus, effectiveness in ethnomathematics-based materials should be broadened to include identity, agency, and participation, not only cognitive outcomes.

Taken together, the high validity, practicality, and effectiveness of the ethnomathematics-based geometry transformation textbook show that local culture can serve as a solid foundation, not a constraint, for developing mathematical literacy (Helgevold & Moen, 2015; Heyd-Metzuyanim et al., 2021; Susanta et al., 2023). The textbook functions as a concrete model of how to connect policy discourses (Merdeka Curriculum, Pancasila student profile, literacy agendas) with classroom realities and cultural diversity. The main challenge now shifts from "can it work?" to "how can it be scaled and adapted responsibly in other contexts?". Answering this question requires collaboration among textbook developers, teachers, local cultural experts, and policymakers so that similar initiatives in other regions retain both mathematical quality and cultural authenticity.

Conclusion

The results of this study show that the ethnomathematics-based geometry transformation textbook developed has excellent quality and is suitable for use in classroom instruction. The textbook meets high criteria of validity in terms of content, presentation, construction, and readability. It is considered very practical by both teachers and students because it is easy to use, engaging, and closely connected to the local cultural context, especially the Rongkong culture. The positive responses from teachers and students indicate that this book supports a more contextual and meaningful learning process. In addition, the use of this textbook has been shown to be effective in improving students' mathematical literacy, as reflected in the increase in their learning outcomes and their active involvement during learning. Overall, this textbook can be regarded as a valuable innovation for strengthening mathematics learning in schools and is in line with national policies that emphasize contextual, culture-based, and literacy-oriented learning.

However, this study has several limitations. The textbook was implemented in one school and one grade level, so the findings cannot yet be generalized to all school contexts. The effectiveness analysis focused on short-term gains and did not examine long-term retention or transfer of mathematical literacy to other topics. In addition, the study did not explore in depth how differences in teachers' pedagogical skills and understanding of ethnomathematics might influence the quality of implementation. Future research is recommended to test this textbook, or its adapted versions, in different regions and school types, to include delayed posttests, and to analyze students' solution strategies in more detail. Further studies can also develop and evaluate ethnomathematics-based teaching materials for other mathematical topics and integrate them with digital platforms. These steps will help to strengthen the evidence base for ethnomathematics-based textbooks as a strategic means to enhance students' mathematical literacy in diverse cultural settings.

Conflict of Interest

The authors declare that there is no conflict of interest.

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Authors' Contributions

F.S. understands the research ideas presented and collects data. The other two authors (S. A and P) actively participated in the development of theories, methodologies, organization and analysis of data, discussion of results and approval of the final version of the work. All authors declare that the final version of this paper has been read and approved. The total percentage of contributions to the conceptualization, compilation, and correction of this paper is as follows: F.S.: 40%, S.A.: 30%, and P.: 30%

Data Availability Statement

The author states that data supporting the results of this study will be provided by the corresponding author, [S.A], upon reasonable request.

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