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Development of Ethnomathematics-Based Handouts Using the Musi VI Bridge to Improve Elementary Students' Understanding of Plane Geometry

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ABSTRACT

This research is motivated by the low understanding of elementary school students of flat building materials because learning tends to be abstract and less associated with students' real experiences. One of the efforts that can be made is to develop ethnomathematics-based contextual teaching materials that utilize local culture, such as the geometric structure on the Musi VI Bridge in Palembang. This study aims to develop a valid, practical, and effective ethnomathematics-based mathematics handout for elementary school grade IV students. The method used is research and development with a 4D model, which includes define, design, develop, and disseminate stages. The subjects of the study were 28 grade IV students of SD Muhammadiyah 3 Palembang. Data collection techniques used interviews, validation questionnaires, response questionnaires, observations, and learning outcome tests. The results showed that the handouts developed obtained an average validity of 90.3% with the very valid category, student responses of 91% and teachers of 93% with the very practical category, and an increase in learning outcomes from an average of pretest 58.4 to a posttest of 84.6 with an N-Gain value of 0.63 in the medium category. Thus, the ethnomathematics-based mathematics handout of the Musi VI Bridge is stated to be suitable for use because it is able to improve understanding of the concept of building flat while integrating local culture into more meaningful learning.

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1. INTRODUCTION

Mathematics learning in elementary school plays a very important role in laying the foundation for students' logical, analytical, systematic, and creative thinking skills. In this phase, Students begin to develop the ability to understand patterns, shapes, sizes, and spatial relationships, which form the basis for advanced mathematics learning. One of the materials that play a central role is flat building, because this concept is the initial foundation for understanding geometry, measurement, and solving contextual

problems at the next level. However, various studies show that geometry remains one of the subjects students find difficult to understand because it is abstract and often taught procedurally, through memorisation of formulas without adequate visualisation (Jablonski & Ludwig, 2023; Rachmawati et al., 2025; Solihin & Rahmawati, 2024). This condition causes many students to memorise broad, general formulas, but they are unable to understand the meanings of shapes, properties, and the conceptual relationships between buildings.

Mathematics learning in elementary school plays a very important role in laying the foundation for students' logical, analytical, systematic, and creative thinking skills. In this phase, Students begin to develop the ability to understand patterns, shapes, sizes, and spatial relationships, which form the basis for advanced mathematics learning. One of the materials that play a central role is flat building, because this concept is the initial foundation for understanding geometry, measurement, and solving contextual problems at the next level. However, various studies show that geometry remains one of the subjects students find difficult to understand because it is abstract and often taught procedurally, through memorisation of formulas without adequate visualisation (Jablonski & Ludwig, 2023; Rachmawati et al., 2025; Solihin & Rahmawati, 2024). This condition causes many students to memorise broad, general formulas, but they are unable to understand the meanings of shapes, properties, and the conceptual relationships between buildings.

These difficulties reveal a gap between the formal concepts taught in the classroom and students' concrete experiences in daily life. Recent research confirms that learning geometry at the basic level requires visual media and real context so that students can construct the concepts meaningfully (Avitasari et al., 2025; Mandasari et al., 2025). However, one factor that causes this condition is the limited teaching materials available to teachers. In many elementary schools, teachers still predominantly use main textbooks and worksheets that focus on routine practice questions. This kind of teaching material has not provided students with sufficient space to explore concepts through the surrounding environment. In fact, the characteristics of elementary school students who are still in the concrete operational stage require presenting material that is simple, visual, and close to their daily experiences (Bognar et al., 2025).

In this context, handouts are one of the forms of teaching materials with great potential as an alternative in learning. The handout is structured in a concise, systematic manner and emphasises the core material, making it easier for students to understand the concepts gradually. In addition, the handouts allow for the integration of images, illustrations, contextual examples, and exercises tailored to students' learning needs. The use of handouts has also been shown to increase students' focus on the main idea of the material, compared to textbooks that are too broad in scope (Krapf & Pfefferkorn, 2022; Novera et al., 2022; Purba et al., 2024). With a simpler, more targeted presentation, handouts can help students build a deeper understanding of how to build a flat building.

To make mathematics learning less abstract, handouts should be linked to contexts close to students' lives through an ethnomathematical approach, integrating mathematical concepts with the culture, artefacts, traditions, and environment of the local community. Recent studies show that ethnomathematics is an important trend in mathematics education because it can connect formal knowledge with students' cultural experiences (Gumala & Syifa, 2025; Kabuye Batiibwe, 2024). This approach is very effectively applied to geometric materials because many elements of local culture contain the concepts of shapes, patterns, lines, angles, and symmetry. Various studies have shown that building architecture, traditional houses, fabric motifs, regional games, and historical buildings have great potential as contexts for flat building learning (Avitasari et al., 2025; Chen, 2024).

In the context of Palembang City, one local object with great potential for integration into mathematics learning is the Musi VI Bridge. The Musi VI Bridge, built in 2015, is one of the bridges that connect the *ulu* and *ilir* parts of Palembang City. This bridge is not only the infrastructure connecting the city but also a representation of the local identity of Palembang's people. The bridge frame structure features various flat geometric shapes, including triangles on the support frame, rectangles on the bridge body, parallel lines on the fence, and angles in the support construction. These elements are highly

relevant to flat building materials at the elementary school level and can serve as a concrete learning resource for students.

The use of the Musi VI Bridge as an ethnomathematical context has two main advantages. First, students can learn through objects close to their lives, making the concept more concrete. Second, learning also instils local cultural values and a sense of belonging to regional icons. Various ethnomathematical studies have shown that the use of local cultural artifacts in geometry learning can significantly increase student motivation, engagement, and learning outcomes (Mandasari et al., 2025). In addition, the use of ethnomathematics-based handouts allows for a more structured presentation of material as students are directed to observe the illustrations of the Musi VI Bridge, identify geometric shapes, compare the properties of buildings, and solve contextual problems based on the surrounding environment.

Although research on ethnomathematics in geometry has been well developed, studies that specifically develop ethnomathematics-based handouts for the Musi VI Bridge on flat building materials for elementary school students are still very limited. Most previous research has focused on traditional houses, weaving, or fabric motifs, so the use of modern local icons of Palembang City as a basis for developing teaching materials remains rare. Therefore, this research has novelty in the use of the Musi VI Bridge as a modern local cultural context in mathematics teaching materials. Based on this description, the development of ethnomathematics-based handouts on the Musi VI Bridge is important as an effort to produce valid, practical, and effective teaching materials to improve elementary school students' understanding.

2. METHODS

This research uses a Research and Development (R&D) approach with a 4D model developed by Thiagarajan, which includes the define, design, develop, and disseminate stages (Sihombing, 2024). This approach was chosen to produce a product in the form of a mathematics handout based on the ethnomathematics of the Musi VI Bridge on flat building materials that are in accordance with the needs of elementary school students. The subjects of the study were 28 grade IV students of SD Muhammadiyah 3 Palembang.

a. Define Stage: During the defining stage, the researcher performed a needs analysis to detect problems within the learning process, as well as to establish the features of the learners and the curriculum. Data were gathered by interviewing the fourth-grade teacher and analyzing the current curriculum and textbooks used in mathematics. This stage concentrated on pinpointing the issues that the learners face when comprehending plane geometry and the necessity of using context-based instructional materials appropriate for the culture of Palembang.
b. Design Stage: In the design phase, the researcher created the first version of the mathematics handout based on ethnomathematics. The steps involved in designing the handout were setting learning goals, choosing geometrical concepts related to the Musi VI Bridge, creating visualizations, providing examples, exercises, and questions to assess knowledge. Special consideration was paid to visual design, formatting, and incorporating ethnomathematical features suitable for Grade IV elementary school children.
c. Develop Stage: Validation of the developed draft occurred through expert validation, revisions, and limited field testing. Three experts validated the draft handout, including a material expert, a media expert, and a language expert. Validation of the draft occurred using the following criteria through a Likert scale questionnaire:

Table 1. Criteria of Validity

Percentage	Criteria
81%–100%	Very Valid
61%–80%	Valid
41%–60%	Quite Valid
0%–40%	Not Valid

If the product received an average rating of at least 80%, it would be deemed valid. Subsequent changes were made to the product based on expert evaluation. The improved version of the handout was then administered to 28 fourth graders. It is worth mentioning that the number of participants used during this study is sufficient for the initial testing stage in developmental research, since it is one whole class (typical for 4D model experiments).

d. Disseminate Stage: In the disseminate stage, the finalized handout was distributed to the fourth-grade teacher for implementation in actual classroom learning. Teacher feedback was collected to assess the potential for wider use.

The research procedure begins with an analysis of learning needs, student characteristics, and the concept of flat building that is relevant to the context of the Musi VI Bridge. Furthermore, handout design, validation by material experts, media experts, and linguists, product revisions, and limited trials to students were carried out. The research instruments include interview guidelines, expert validation sheets, student and teacher response questionnaires, observation sheets, and flat building concept understanding tests. Data was collected through interviews, questionnaires, observations, and learning outcome tests, then analyzed quantitatively and qualitatively. The tools were designed by the researcher and evaluated by experts. Even though reliability testing procedures like Cronbach's Alpha test were not done since it was still in the development phase, the validation procedure done by experts ensured content validity of the tools. Quantitative analysis was performed to determine the level of validity, practicality, and effectiveness of the product through the percentage of the Likert scale and the calculation of N-Gain, while qualitative analysis was used to describe the validator's input and the feasibility of using the handout in learning.

3. FINDINGS AND DISCUSSION

3.1 Findings

The discussion of the results of this research is focused on the analysis of the process and quality of ethnomathematics-based mathematics handout products of the Musi VI Bridge, which was developed to improve the understanding of flat building among elementary school students. The discussion description integrates the results of expert validation, practicality of use, and product effectiveness based on data on student learning outcomes. In addition to displaying quantitative data, the discussion also emphasized descriptive aspects in the form of the product revision process, the relationship with the characteristics of elementary school students, and the relevance of the local cultural context of Palembang. Thus, this discussion not only shows the quality of the products produced but also explains how each stage of development contributes to the achievement of research objectives.

The discussion of this research is prepared based on the stages of the 4D model, namely define, design, develop, and disseminate, with a focus on product quality, which includes the validity, practicality, and effectiveness of ethnomathematics-based mathematics handouts of the Musi VI Bridge on flat building materials for grade IV students of SD Muhammadiyah 3 Palembang. The description of the discussion not only explains the numerical results but also relates them to the theory of teaching materials, ethnomathematics, and the characteristics of school students.

At the definition stage, the results of the needs analysis show that flat wake learning in grade IV is still dominated by the use of packaged books and routine practice questions. Based on interviews with class teachers, students often have difficulty identifying flat shapes on real objects and tend to only memorize broad formulas and circumference. This condition is in line with the characteristics of elementary school students who are still in the concrete operational stage, so they need visual and contextual teaching materials. Therefore, the development of ethnomathematics-based handouts that utilize the context of the Musi VI Bridge is seen as relevant because the bridge structure contains elements of triangles, rectangles, parallel lines, and angles that are close to the lives of students in Palembang.

Furthermore, to clarify the structure of the content of the developed product, Table 1 presents the main components of the handout along with a description of each part. This table serves to systematically explain the elements that make up the handout that support the achievement of learning objectives.

Table 2. **Developed Handout Components**

No.	Components	Description
1.	Cover	Contains title, image of the Musi VI Bridge, and student identity
2.	Material	Build a flat based on the context of the Musi VI bridge Palembang
3.	Activities	Identify form, nature, and contextual problems
4.	Evaluation	Formative exercises and tests

In the design stage, the researcher compiled a handout with components: cover, instructions for use, learning objectives, flat building materials, illustrations of the Musi VI Bridge, examples of contextual problems, shape identification activities, and evaluation exercises. Selecting an attractive visual design with a bridge image aims to increase students' attention. The integration of local context on each subsubject helps students connect geometric concepts with real objects. For example, in the triangle material, students are asked to observe the bridge support frame, while in the rectangular material, students identify the shape of the bridge body and the vehicle path.

As part of the development phase, the designed handouts are then validated by three validators to assess content suitability, display quality, and language accuracy. The recapitulation of the expert validation results in Table 2 shows that the product achieved a very valid category, with an average percentage of 90.3%.

Table 3. Expert Validation Results

Validator	Percentage	Categories
Material Expert	92%	Very valid
Media members	89%	Very valid
Linguist	90%	Very valid
Average	**90.30%**	**Very valid**

Validity testing was done using three experts, namely, a material, media, and language expert. The average of all validity scores was 90.3 percent, which is included in the very valid category. Scores of material, media, and linguist experts were 92%, 89%, and 90%, respectively. From the result above, it can be said that the handout meets the requirements for accuracy in content, media design, and linguistic aspects intended for Grade IV students. The improvement of the handout was made from the feedback of the experts, especially in terms of integrating geometrical concepts to bridges illustration, balanced layout, and simplifying instructions. The development stage shows that the product developed meets the criteria very well (Cook & Hatala, 2016). In addition to quantitative data, the expert validation process in the handout section was also analyzed descriptively in the form of errors found and improvements made.

The validation results not only show the percentage feasibility of the product, but also produce revision records that are substantive and technical (Abellán et al., 2020). These notes include the accuracy of the visual design, the depth of the material, the readability of the language, the clarity of the illustrations, and the contextuality of the practice questions. All validator inputs are used as the basis for improving the handout, as summarized in the following table.

Table 4. Error Description and Handout Fixes Based on Expert Validation

Aspects	Validator Errors/Findings	Repairs Made
Cover display	Less prominent titles and images Musi VI Bridge is not proportional	The size of the title is enlarged, the typeface is made more assertive, and the image is adjusted to focus on the geometric structure
Material	The explanation of the nature of a flat building is still too short	Added descriptions of the properties of triangles, rectangles, and examples in the bridge section
Language	Instructions for use sentences are too long for elementary school students	Sentences are simplified into short, communicative instructions
Illustration	There is no geometric shape marker on the bridge photo yet	Added auxiliary lines, corner symbols, and accent colors on triangle and rectangle shapes
Practice questions	The question is still predominantly procedural	Contextual questions were added based on the fences, poles, and paths of the Musi VI Bridge

Descriptively, the material expert validator emphasized that the content of the handout was in accordance with the learning achievements of flat building, but still needed to strengthen the relationship between the formal concept and the real object of the Musi VI Bridge. Therefore, the researcher added a direct shape identification activity to the bridge drawing. Media expert validators provide input on aspects of layout, especially the balance between text and images, so that students don't get tired of reading quickly. Meanwhile, linguist validators suggest the use of simpler sentences, the selection of terms that are familiar to grade IV students, and the consistency of punctuation usage.

After all these inputs were implemented, the quality of the handout improved both in terms of content and appearance. This descriptive revision strengthens the results of quantitative validation and shows that the product has gone through a systematic refinement process before being tested on students.

As a form of visual evidence of the product improvement process, the results of the handout revision are presented through a comparison of conditions before and after expert validation. This presentation aims to show significant changes in the aspects of cover design, depth of material, and quality of practice questions so as to emphasize that the product has gone through a systematic refinement stage.

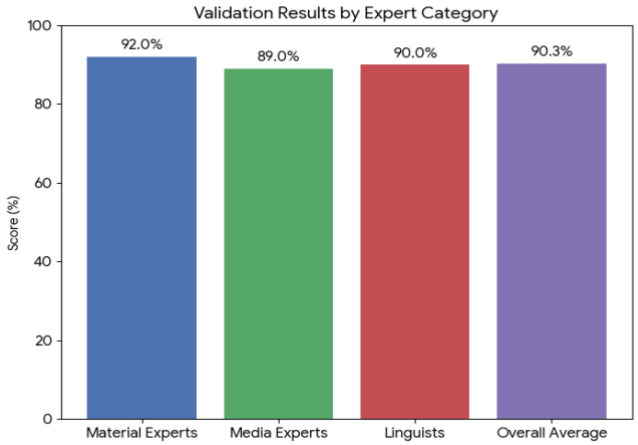

Figure 1. Comparison of Handouts Before and After Revision

The addition of this comparison visual aims is to clarify the product revision process in real terms. With visual before-and-after evidence, readers can see firsthand the improvement in the quality of the handout, both in terms of appearance, content, and relevance to the ethnomathematical context. It also reinforces that the developed products have undergone a systematic validation and revision process in accordance with development research standards. Based on the results of the validation of material experts, an average score of 92%, media experts, 89%, and linguists, 90%, the overall average reached 90.3% with a very valid category. The validator provided several suggestions for improvement, such as simplifying the language in the work instructions, adding parallel line illustrations on the bridge fence, and adjusting the font size to better suit the characteristics of elementary school students. After the revision, the handout was tested on a limited basis on 28 grade IV students of SD Muhammadiyah 3 Palembang.

A limited trial was conducted on grade IV students of SD Muhammadiyah 3 Palembang to see the practicality of using handouts in real learning situations. During the learning process, students demonstrate active involvement in reading the material, observing geometric shapes in the illustrations of the Musi VI Bridge, and completing contextual practice questions available in the handout. Teachers can also easily use handouts as companion teaching materials, especially in associating the concept of a flat building with objects that are close to students' lives. Based on the implementation of the trial, the level of practicality of the product was then analyzed through the responses of students and teachers presented in Table 4.

Table 5. Student and Teacher Response Results

Respondents	Percentage	Categories
Students	91%	Very practical
Teacher	93%	Very practical

The results of the practicality test showed that the handout received a positive response from students and teachers. The student response questionnaire obtained a percentage of 91% with the category of very practical, while the teacher's response reached 93%. Students stated that the image of the Musi VI Bridge made it easier for them to recognize the shape of a flat building in their daily lives. Teachers also assessed that the handouts helped the learning process because the material was concise, illustrative, and in accordance with the local context. These findings suggest that the use of local culture in teaching materials can increase student learning engagement.

To determine the effectiveness of the handout in improving students' understanding of flat buildings, an analysis of the results of the pretest and posttest was carried out. The recapitulation of the average score and the acquisition of NGain is presented in Table 5.

Table 6. Pretest and Posttest Results

Tests	Average
Pretest	58.4
Posttest	84.6
N-Gain	0.63

Based on the data in Table 4, it can be seen that there is an increase in student learning outcomes after using the ethnomathematics-based handout of the Musi VI Bridge. The efficiency of the handout was determined based on the differences between the learning outcomes of students before and after implementing the handout. The mean score in the pre-test was 58.4, which grew to 84.6 in the post-test. The N-Gain score was 0.63 and was classified as medium gain. This score illustrates that the developed ethnomathematical handout positively influenced the comprehension of the concepts of plane geometry

among the students. It was found that the students were capable of identifying different plane shapes, such as triangles and rectangles. They also became aware of the properties and uses of these shapes and could answer relevant questions concerning the Musi VI Bridge. The incorporation of the bridge, which is part of the locals' culture, contributed to bridging the gap between abstract math concepts and students' daily experiences. The developed handout satisfied the requirements of validity, practicality, and effectiveness. To clarify the difference between pretest and posttest scores, the increase is visualized in the form of a graph in Figure 2.

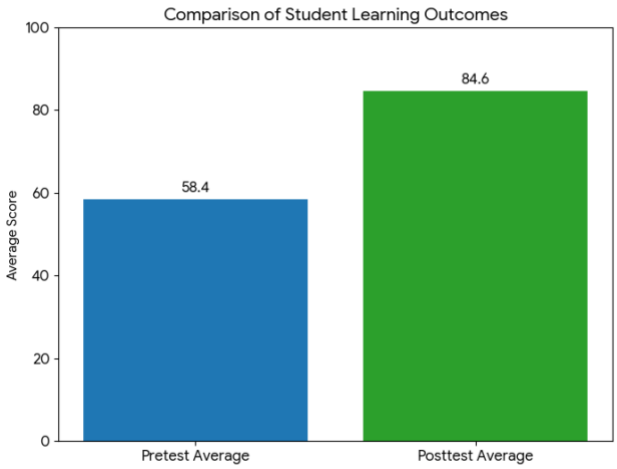

Figure 2. Graph of student learning outcomes improvement

The effectiveness of the handout can be seen from the improvement of student learning outcomes on the flat building comprehension test. The average pretest score of 58.4 increased to 84.6 in the posttest. The result of the calculation of NGain of 0.63 was in the medium to high category, which indicates an increase in conceptual understanding after the use of the handout. For example, before the use of the handout, many students were not able to identify the shape of the triangle on the bridge frame, but after learning, most students were able to explain the types of triangles, their properties, and relate them to the bridge structure.

These findings reinforce that ethnomathematical approaches are effectively used in geometric materials, especially flat buildings. The context of the Musi VI Bridge not only helps students understand the concept concretely, but also fosters a sense of closeness to the local culture and environment. The novelty of this research lies in the use of modern icons of the city of Palembang as the basis for the development of handouts, in contrast to previous research, which used more in the context of traditional houses, *songket*, or traditional motifs.

At the disseminate stage, the handout was disseminated on a limited basis to grade IV teachers of SD Muhammadiyah 3 Palembang as accompanying teaching materials on flat building materials. The teacher gave input that this handout has the potential to be further developed on other geometry materials, such as building space and symmetry. Thus, the results of the study show that the ethnomathematics-based mathematics handout of the Musi VI Bridge meets valid, practical, and effective aspects, so that it is feasible to use it to improve the understanding of elementary school students' flat buildings.

3.2. Discussion

The result of the current study indicates that the use of ethnomathematics in creating the handout based on the Musi VI Bridge is valid, practical, and effective in improving elementary school students' comprehension of plane geometry.

This is in line with other studies that use ethnomathematics in designing mathematics educational media (Avitasari et al., 2025; Jablonski & Ludwig, 2023; Solihin & Rahmawati, 2024). Such integration

of local culture in math lesson designs is highly beneficial for improving learning outcomes. Indeed, ethnomathematics can help create a more meaningful connection between mathematical concepts and the life experience of the learner.

This can be attributed to Piaget's (2003) concept of cognitive development in children. According to this theory, fourth graders belong to the concrete operational stage, where their thinking becomes increasingly logical, but they still benefit from experiencing things rather than memorizing abstract concepts. In this regard, Musi VI Bridge was instrumental since it offered them a chance to build geometrical concepts by observing triangles in its support structures, rectangles in the deck, and parallel lines in fences.

The discovery thus reinforces the importance of contextual learning in mathematics education. Learning that is directly linked to students' surroundings and cultures makes the lessons more meaningful and memorable for them. In particular, the inclusion of contemporary symbols in the lessons, like the Musi VI Bridge in this case, rather than just the conventional materials, was especially effective since it created a greater sense of ownership and respect towards their immediate surroundings during mathematics lessons.

In addition, the high practicality score implies that the handout was able to lessen the students' cognitive load, making it easier for them to learn about the topic. These results are in line with prior studies, which found that ethnomathematics-based educational resources have been found to yield positive cognitive and affective results on students, increasing their interest in the subject matter and their pride in their culture (Avitasari et al., 2025; Bognar et al., 2025). As a conclusion, using ethnomathematics by incorporating the Musi VI Bridge in lessons effectively bridges the divide between classroom geometry lessons and students' lived experiences in their immediate surroundings.

4. CONCLUSION

This research succeeded in developing an ethnomathematics-based mathematics handout of the Musi VI Bridge for flat building materials for grade IV elementary school. The results showed that the handouts developed obtained an average validity of 90.3% (very valid), practicality levels of 91% (students) and 93% (teachers) (very practical), and effectiveness with an increase in average score from 58.4 to 84.6 and an N-Gain of 0.63 (medium category). This research makes a new contribution to the development of mathematics teaching materials by utilizing modern local cultural artifacts in the form of the Musi VI Bridge. The main novelty lies in the use of contemporary infrastructure as an ethnomathematical context, which has been rarely explored compared to traditional artifacts.

The implication of this research is the importance of integrating the local cultural context in mathematics teaching materials. For teachers, this handout can be a contextual learning model that increases understanding of concepts while strengthening students' sense of pride in regional identity. For the curriculum, these findings support the strengthening of culturally and contextually relevant learning approaches in accordance with the characteristics of elementary school students at the concrete operational stage. This research has limitations, namely, the trial was carried out in a limited way in one class in one school. Therefore, generalization of results still needs to be done carefully. Further research is suggested to test the effectiveness of these handouts on a wider scale in some schools, develop teaching materials for other geometry materials (such as building spaces and symmetry), and create interactive digital versions based on QR Codes or augmented reality.

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