

Research Article

Validity of Ethnomathematics-Based Student Worksheets Using the Kepahiang Traditional House in Geometric Transformations for Mathematical Conceptual Understanding

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Abstract: Learning geometric transformations requires a strong conceptual understanding due to their abstract nature. One effort to enhance students' conceptual understanding of mathematics is through the development of contextual and meaningful instructional materials that incorporate local culture. This study is a research and development (R&D) study employing the 4D model (Define, Design, Develop, and Disseminate) aimed at examining the validity of the developed Student Worksheets. The validation of the Student Worksheets was conducted by two experts in mathematics education who evaluated the aspects of content feasibility, media, and language and readability. The data were analyzed using descriptive quantitative methods with percentage scores to determine the level of validity of the Student Worksheets. The results showed that the developed Student Worksheets obtained a validity percentage of 93.75% for the content feasibility aspect (very valid), 80.77% for the media aspect (valid), and 87.50% for the language and readability aspect (very valid), with an overall average of 87.34%, which falls into the very valid category. Based on these results, the ethnomathematics-based Student Worksheets using the Kepahiang Traditional House context are considered feasible for use as supporting instructional materials in learning geometric transformations.

Keywords: Cultural Heritage; Ethnomathematics; Geometric Transformations; Kepahiang Traditional House; Student Worksheet.

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1. Introduction

Mathematics learning plays a fundamental role in developing students' conceptual understanding of mathematics as a foundation for logical, systematic, and reflective thinking. Conceptual understanding in mathematics is not merely related to the ability to memorize formulas or apply procedures, but is reflected through several indicators, namely students' ability to restate a concept, classify objects or problems based on certain properties, represent concepts in various forms, logically connect concepts, and apply concepts in meaningful contexts (Aurelyasari & Nur, 2023; Sengkey et al., 2023). However, numerous studies indicate that mathematics instruction in schools is still predominantly characterized by procedural and symbolic approaches, resulting in students' conceptual understanding not being optimally developed (Lukman, 2021).

One effort to enhance students' conceptual understanding of mathematics is through contextual and meaningful learning that connects mathematical concepts with students' real-life experiences. This approach is aligned with constructivist perspectives, which emphasize that knowledge is actively constructed through interactions between new experiences and learners' existing cognitive structures (Arafah et al., 2023; Handayani et al., 2023; Pramatha et al., 2022). In classroom practice, Student Worksheets serve as strategic instructional

materials to facilitate active, exploratory, and student-centered learning activities. Systematically and contextually designed Student Worksheets can support students in constructing mathematical concepts through activities of observing, reasoning, and reflecting, rather than merely solving routine problems (Lestisia et al., 2023; Mahmudi et al., 2022; Yanti et al., 2022).

One mathematics topic that requires strong visualization skills and deep conceptual understanding is geometric transformation. The concepts of translation, reflection, rotation, and dilation are abstract in nature because they involve changes in the position and size of objects without concrete forms that can be directly observed. This condition often causes students to experience difficulties in understanding the geometric meaning of transformations, distinguishing between different types of transformations, and visually representing these concepts. As a result, learning tends to occur mechanically through the memorization of rules or formulas (Hanipah et al., 2022; Pasandaran et al., 2021; Riwayati et al., 2023). Therefore, instructional materials are needed to bridge the abstract nature of geometric transformations with concrete representations that are closely related to students' experiences.

In this context, ethnomathematics offers a relevant approach for connecting mathematics with local culture. (Soebagyo et al., 2021) state that ethnomathematics is an approach that integrates local cultural activities with mathematical concepts, thereby making learning more meaningful. The integration of ethnomathematics into mathematics instruction not only enriches the learning context but also has the potential to strengthen students' conceptual understanding of mathematics, particularly in their ability to connect concepts, represent mathematical ideas, and apply them in real-life situations (Delviana & Putra, 2022). Thus, the ethnomathematics approach can transform procedurally oriented mathematics learning into learning that is contextual and meaningful.

One form of ethnomathematics implementation that can be utilized in learning is through local cultural heritage. In Bengkulu Province, particularly in Kepahiang Regency, there is a traditional house known as Bubungan Lima, which possesses rich mathematical potential. The architectural structure, ornamental patterns, and spatial layout of the Kepahiang Traditional House represent various concepts of geometric transformation, such as symmetry in reflection, pattern shifts in translation, and motif rotations. The use of the traditional house context in Student Worksheets enables students to observe and explore geometric transformation concepts through tangible cultural objects, thereby making learning more contextual and meaningful (Hidayati et al., 2025).

To support the integration of this cultural context into learning, the development of ethnomathematics-based Student Worksheets on geometric transformation material must be accompanied by product validity testing. Validity serves to ensure the alignment of content, construct, and presentation with learning objectives and students' characteristics (Pakaya et al., 2025). Several studies on the development of culture-based instructional materials emphasize that expert validation results are a primary indicator of product quality prior to classroom implementation (Bunga et al., 2025; Maisaroh & Permatasari, 2024; Musyrifah et al., 2022).

Based on these considerations, this study was conducted to develop and validate ethnomathematics-based Student Worksheets grounded in the Kepahiang Traditional House on geometric transformation topics, oriented toward students' conceptual understanding of mathematics. This research is expected to contribute theoretically to the development of culture-based instructional materials and practically to supporting teachers in implementing contextual and meaningful geometric transformation learning.

2. Materials and Method

This study employed a Research and Development (R&D) approach aimed at producing ethnomathematics-based Student Worksheets grounded in the Kepahiang Traditional House on geometric transformation topics, oriented toward students' conceptual understanding of mathematics. The development procedure adapted the 4D model proposed by Thiagarajan, which consists of the define, design, develop, and disseminate stages (Santi et al., 2022). However, this study was limited to the develop stage, specifically focusing on product validity testing.

The define stage was conducted through a series of analyses, beginning with curriculum analysis to align the instructional content with the applicable basic competencies. This was followed by an analysis of students' characteristics to identify their cognitive abilities and cultural backgrounds. Subsequently, a material analysis was carried out to examine the essential concepts of geometric transformations, including translation, reflection, and rotation.

At the design stage, activities focused on developing research instruments and media designs. This stage resulted in the initial prototype of the Student Worksheets by integrating ethnomathematical exploration activities based on the architectural structures of the Kepahiang Traditional House into learning activities oriented toward students' conceptual understanding of mathematics.

The develop stage was conducted through expert validation to assess the theoretical feasibility of the product. The validation involved two experts in mathematics education who evaluated the Student Worksheets using a four-point Likert-scale validation instrument covering content feasibility, media aspects, and language and readability. Following the evaluation process, revisions were made based on the validators' suggestions and feedback to improve both the technical quality and the substantive content of the Student Worksheets. The validation data were analyzed using descriptive quantitative methods by calculating percentage scores based on the following formula (Riduwan, 2019):

$$P = \frac{\sum x}{\sum xi} \times 100\%$$

Description:

P = Validity percentage

$\sum x$ = Total score obtained

$\sum xi$ = Maximum possible score

The percentage scores were employed to determine the feasibility level of the Student Worksheets according to the established validity criteria, as shown in Table 1.

Table 1. Validity Criteria.

Description	Criteria
81% < V ≤ 100%	Very Valid
61% < V ≤ 80%	Valid
41% < V ≤ 60%	Moderately Valid
21% < V ≤ 40%	Low Validity
0% < V ≤ 20%	Not Valid

(Riduwan, 2019)

The Student Worksheets were deemed valid when the expert assessments met a minimum validity level of valid. Recommendations provided by the validators served as the basis for product revision and improvement.

3. Results and Discussion

Result

The development process of the ethnomathematics-based Student Worksheets grounded in the Kepahiang Traditional House on geometric transformation material was carried out using the 4D model, beginning with the define stage. Based on the results of curriculum analysis and students' characteristics analysis, a need for strengthening conceptual understanding in geometric transformation material at Phase F was identified. Therefore, the material analysis focused on the concepts of translation, reflection, and rotation integrated with the local cultural context. The selection of the Kepahiang Traditional House as the main object was based on its architectural characteristics, which strongly represent mathematical

concepts, such as the regularity of symmetrical patterns in fence carvings and rotational principles found in sunflower ornaments.

At the design stage, media designs and research instruments were developed. The Student Worksheets were designed to facilitate cultural exploration activities while supporting the discovery of matrix-based geometric transformation concepts. The detailed design of the developed Student Worksheets is presented in Table 2.

Table 2. Description of the Student Worksheets Media Structure Design.

Student Worksheets Section	Design Description
Cover Page	Displays the main visual of the Kepahiang Traditional House, the title, and identification information.
Cultural Exploration & Basic Concepts	Contains learning objectives, learning instructions, and a brief narrative explaining the philosophical meaning of the architectural design of the Kepahiang Traditional House.
Matrix Concept (Material)	Explains the concept of “Geometric Codes” (matrix formulas) for translation, reflection, and rotation.
Core Activities (Exploration 1–3)	Presents exploratory activities that model architectural elements (pentagonal lispang motifs, terrace fence symmetry, and sunflower ornaments) into the Cartesian coordinate system to be solved using matrix-based translation, reflection, and rotation principles.
Self-Reflection	Provides a self-evaluation worksheet.

After the Student Worksheets prototype was completed, the development stage proceeded with an expert validation process to assess the theoretical feasibility of the developed product. At this stage, the validators provided various suggestions related to pedagogical aspects, language use, and the presentation of the Student Worksheets. These suggestions served as the basis for revising and refining the Student Worksheets to ensure alignment with the learning objectives and students’ characteristics.

Following the validators’ recommendations, revisions were made to several parts of the designed Student Worksheets prior to conducting the final validity assessment. The revisions included improvements in wording, the flow of material presentation, and the clarity of learning activities, which are described as follows:

Table 3. Design Transformation of the Student Worksheets.

Student Worksheets Design Before Revision



1. Coba tarik garis vertikal tepat ditengah ukiran pagar teras. Apakah bagian kiri dan kanan terlihat sama? Disebut apakah ini dalam geometri?

Validators’ Suggestion:

The wording should be revised using simpler and more easily understood language for students.

Student Worksheets Design After Revision



1. Coba tarik garis tegak lurus tepat ditengah ukiran pagar teras. Apakah bagian kiri dan kanan terlihat sama? Disebut apakah ini dalam geometri?

Student Worksheets Design Before Revision



Gambar 3. Ukiran Pagar Teras

2. KODE KESEIMBANGAN (REFLEKSI)

Digunakan untuk mengecek kesimetrisan ukiran pagar teras.

Sumbu X(M_x): $\begin{pmatrix} x' \\ y' \end{pmatrix} = \begin{pmatrix} 1 & 0 \\ 0 & -1 \end{pmatrix} \begin{pmatrix} x \\ y \end{pmatrix}$

Sumbu Y(M_y): $\begin{pmatrix} x' \\ y' \end{pmatrix} = \begin{pmatrix} -1 & 0 \\ 0 & 1 \end{pmatrix} \begin{pmatrix} x \\ y \end{pmatrix}$

Garis $y = x$ ($M_y = x$): $\begin{pmatrix} x' \\ y' \end{pmatrix} = \begin{pmatrix} 0 & 1 \\ 1 & 0 \end{pmatrix} \begin{pmatrix} x \\ y \end{pmatrix}$

Garis $y = -x$ ($M_y = -x$): $\begin{pmatrix} x' \\ y' \end{pmatrix} = \begin{pmatrix} 0 & -1 \\ -1 & 0 \end{pmatrix} \begin{pmatrix} x \\ y \end{pmatrix}$

Validators' Suggestion:

The derivation of the formula should not be presented instantly; instead, it should be developed through a coordinate exploration process.

Student Worksheets Design After Revision

KODE PERUBAHAN BENTUK

$A(x, y)$	M_x	$A'(x, -y)$
$A(x, y)$	M_y	$A'(-x, y)$
$A(x, y)$	$M_{y=x}$	$A'(y, x)$
$A(x, y)$	$M_{y=-x}$	$A'(-y, -x)$
$A(x, y)$	$M_{y=2x}$	$A'(2x, -y)$
$A(x, y)$	$M_{y=-2x}$	$A'(-2x, -y)$

KODE PENCERMINAN (REFLEKSI)

Digunakan untuk mengecek kesimetrisan ukiran pagar teras.

$\begin{pmatrix} x' \\ y' \end{pmatrix} = \begin{pmatrix} x \\ y \end{pmatrix} + \begin{pmatrix} h \\ k \end{pmatrix}$

Student Worksheets Design Before Revision

Instruksi Pengerjaan

Berdasarkan diagram yang diberikan, pola dasar pertama memiliki titik-titik koordinat:

- A(-4, 7)
- B(-2, 7)
- C(-5, 4)
- D(-1, 4)
- E(-3, 3)

Pola tersebut kemudian digeser (ditranslasi) menjadi pola baru dengan koordinat bayangan:

- A'(-4, -2)
- B'(-2, -2)
- C'(-5, -5)
- D'(-1, -5)
- E'(-3, -6)

Bandingkan koordinat titik asal koordinat bayangan dan hitunglah sejauh mana titik tersebut bergeser!

Validators' Suggestion:

It was suggested that the task instructions employ symbolic notation without directly specifying coordinate values.

Student Worksheets Design After Revision

Instruksi Pengerjaan

Berdasarkan diagram yang diberikan, pola dasar pertama memiliki titik-titik koordinat (A, B, C, D, E). Pola tersebut kemudian digeser menjadi pola baru dengan koordinat bayangan (A', B', C', D', E').

Bandingkan koordinat titik asal koordinat bayangan dan hitunglah sejauh mana titik tersebut bergeser!

Student Worksheets Design Before Revision

 **Refleksi Mendalam**

Setelah menghitung presisi ornamen pagar, lisplang dan bunga, apa pendapatmu tentang kecerdasan arsitek/pengrajin Rumah Adat Kepahiang di masa lalu?
 Jawaban: _____

Validators' Suggestion:

It was suggested that the question wording be made more operational and focus on students' mathematical abilities to ensure alignment with the learning objectives.

Student Worksheets Design After Revision

 **Refleksi Mendalam**

Setelah menghitung ketepatan ornamen pagar, lisplang, dan bunga matahari pada bagian depan atap, apa pendapatmu tentang kemampuan bermatematika para tukang yang membangun Rumah Adat Kepahiang pada zaman dahulu?
 Jawaban: _____

After the revision process was completed, the Student Worksheets prototype was formally subjected to validity testing. The validation was conducted on three main aspects, namely content/material feasibility, media aspects, and language and readability, as specified in the expert validation instrument.

Content/Material Feasibility Aspect

The content/material feasibility aspect includes the alignment of the material with the learning outcomes and learning objective flow, the accuracy of geometric transformation concepts, the suitability of the Kepahiang Traditional House context with the material, and the coherence of learning activities. A summary of the validation results for the content feasibility aspect is presented in Table 4.

Table 4. Validation Results of the Content/Material Feasibility Aspect.

Aspect	Maximum Score	Average Score	Percentage (%)	Category
Content/Material Feasibility Aspect	48	45	93,75	Very Valid

These results indicate that the Student Worksheets have met the content feasibility criteria with a very valid category, signifying that the geometric transformation material and the integration of ethnomathematics based on the Kepahiang Traditional House have been systematically and appropriately developed.

Media Aspect

The media aspect includes the cover design, content layout, arrangement of visual elements, illustrations and images, font usage, and the appropriateness of colors and overall appearance of the Student Worksheets. A summary of the media aspect validation results is presented in Table 5.

Table 5. Validation Results of the Media Aspect.

Aspect	Maximum Score	Average Score	Percentage (%)	Category
Media	52	42	80,77	Valid

Based on these results, the media aspect of the Student Worksheets falls into the valid category, indicating that, in general, the appearance and design of the Student Worksheets support the learning activities, although improvements in layout and visualization are still required.

Language and Readability Aspect

The language and readability aspect includes language clarity, conformity with standard language conventions, clarity of instructions, and consistency in the use of mathematical terminology. The validation results for the language and readability aspect are presented in Table 6.

Table 6. Language and Readability Aspect Validation Results.

Aspect	Maximum Score	Average Score	Percentage (%)	Category
Language and Readability	16	14	87,50	Very Valid

These results indicate that the language used in the Student Worksheets is clear, communicative, and in accordance with proper and correct Indonesian language conventions.

Overall Validation Results Summary

A summary of the overall validation results of the Student Worksheets evaluated by two validators is presented in Table 7.

Table 7. Summary of Overall Validation Results.

Aspect	Percentage (%)	Category
Content/Material Feasibility Aspect	93,75	Very Valid
Media	80,77	Valid
Language and Readability	87,50	Very Valid
Overall Average Score	87,34	Very Valid

Based on the overall validation results, the ethnomathematics-based Student Worksheets grounded in the Kepahiang Traditional House were categorized as very valid and therefore deemed feasible for use as instructional materials.

Discussion

The validation results indicate that the ethnomathematics-based Student Worksheets grounded in the Kepahiang Traditional House meet a very high level of theoretical feasibility, with an average validity percentage of 87.34%. Methodologically, this achievement confirms that the develop stage of the 4D model has successfully synchronized design, content, and cultural context in a coherent manner prior to the implementation stage (Melindawati & Adriantoni, 2022; Rodli et al., 2022). The high validity score reflects that the product is not merely a visual aid, but an academically validated instructional material designed to support the learning of geometric transformations.

The high validity in the content aspect indicates that the Student Worksheets are capable of shifting the learning paradigm from a procedural–mechanistic approach toward a constructive and contextual learning orientation (Liesandra & Nurafni, 2022). Through the integration of the Kepahiang Traditional House architecture, abstract concepts such as translation, reflection, and rotation are represented through concrete visual objects. This finding is consistent with conceptual understanding theory, which emphasizes that learning success is not solely measured by problem-solving performance, but by students' ability to explain meanings and logical relationships among concepts in depth (Kholid et al., 2025).

From a theoretical perspective, the Student Worksheets function as a mediating instrument within Vygotsky's framework. The local cultural context serves as scaffolding that bridges students' everyday experiences with formal mathematical concepts (Azizah & Purwaningrum, 2021). By observing geometric patterns embedded in traditional architectural structures, students are facilitated to learn within the Zone of Proximal Development (ZPD). This process ensures gradual knowledge internalization, in which cultural objects act as cognitive bridges that support the transition from concrete to abstract thinking (Mujtahidah et al., 2025).

The validation support in the media and language aspects also indicates that the developed visual design is capable of minimizing students' cognitive load. The use of communicative language and a contextual layout ensures that students' attention remains focused on mathematical reasoning activities rather than on the complexity of instructional directions (Prihaswati et al., 2023). This is crucial, as effective learning media should present information clearly without distracting students from independently constructing conceptual understanding (Puspita et al., 2025).

The integration of ethnomathematics in this study provides a significant contribution to the literature on mathematics education through the exploration of local architecture. These findings reinforce the argument that incorporating culture into mathematics learning not only enhances conceptual understanding but also fosters active engagement and cultural awareness among students (Arif & Mahmudah, 2022). Overall, the achieved theoretical validity provides a strong foundation indicating that these Student Worksheets are suitable for implementation as an innovative solution to create mathematics learning that is more relevant, humanistic, and contextual (Sugiartha et al., 2025).

4. Conclusion

This study resulted in the development of ethnomathematics-based Student Worksheets grounded in the Kepahiang Traditional House on geometric transformation material, oriented toward students' conceptual understanding of mathematics. Expert validation results indicate that the developed Student Worksheets achieved a validity percentage of 93.75% in the content feasibility aspect (very valid), 80.77% in the media aspect (valid), and 87.50% in the language and readability aspect (very valid), with an overall average of 87.34%, which falls into the very valid category. Based on these results, the ethnomathematics-based Student Worksheets of the Kepahiang Traditional House are theoretically feasible for use as supporting instructional materials in teaching geometric transformations.

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