

VALIDITY OF DISCOVERY-BASED ETHNOMATEMATICS LESSON PLAN: A DEEP LEARNING APPROACH TO THE PYTHAGOREAN THEOREM

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Abstract

The lack of integration of local culture into mathematics teaching, which is usually procedural and abstract in nature, is an obstacle to creating valuable, reflective learning experiences that are appropriate for the educational needs of the 21st century. This study aimed to analyze the validity of ethnomathematics-based lesson plan using the Discovery Learning model and Deep Learning approach in the mystery of the Pythagorean Theorem. The methodology applied is research and development (R&D) using a modified 4D model, focusing on the Develop (D3) stage, involving three validators: an expert lecturer in the subject matter and two mathematics teachers from junior high school as implementers. The evaluation instruments consisted of five aspects: content validity, presentation, language use, integration of the learning model, and technical validity. The results of the validation process indicated that the module is highly valid, with Aiken V values ranging from 0.75 to 1.00. This ethnomathematics-based lesson plan with Pythagorean Theorem material successfully links mathematical concepts with local culture, presents an organized and communicative learning structure, and encourages student exploration and reflection very well. These findings confirm that this learning tool is suitable for use in contextual learning of Pythagorean Theorem material. Future researchers are advised to evaluate the effectiveness of this lesson plan through its application in the classroom and to develop similar teaching tools for other materials that are in line with the local context of students.

Keywords: Deep Learning; Discovery Learning; Ethnomathematics; Pythagorean Theorem; Validity.

Abstrak

Kurangnya penggabungan budaya setempat dalam pengajaran matematika yang biasanya bersifat prosedural dan konsep yang tidak konkret menjadi suatu hambatan dalam menciptakan pengalaman belajar yang berharga, penuh refleksi, dan sesuai dengan kebutuhan pendidikan di era abad ke-21. Penelitian ini bertujuan untuk menganalisis validitas perangkat pembelajaran berbasis pada etnomatematika dengan menggunakan model Pembelajaran Discovery dan pendekatan Deep Learning pada materi Teorema Pythagoras. Metodologi yang diterapkan adalah penelitian dan pengembangan (R&D) menggunakan model 4D yang telah dimodifikasi, yang difokuskan pada tahap Develop (D3) dengan melibatkan tiga orang validator yaitu seorang dosen yang ahli dalam materi dan dua tenaga pengajar matematika dari tingkat SMP sebagai pelaksana. Instrumen penilaian terdiri dari lima aspek yaitu kelayakan isi, penyajian, penggunaan bahasa, integrasi model pembelajaran, dan kelayakan teknis. Hasil dari proses validasi menunjukkan bahwa modul tersebut sangat valid, dengan nilai Aiken V yang berkisar antara 0,75 hingga 1,00. Rencana pembelajaran berbasis etnomatematika dengan materi Teorema Pythagoras ini berhasil mengaitkan konsep matematika dengan budaya setempat, menyajikan struktur pembelajaran yang terorganisir dan komunikatif, serta mendorong eksplorasi dan refleksi siswa dengan sangat baik. Temuan ini menegaskan bahwa perangkat pembelajaran ini cocok untuk diterapkan dalam pembelajaran materi Teorema Pythagoras yang kontekstual. Peneliti selanjutnya disarankan untuk mengevaluasi efektivitas perangkat pembelajaran ini melalui penerapannya di kelas dan mengembangkan perangkat ajar serupa untuk materi lain yang sejalan dengan konteks lokal siswa.

Kata kunci: Etnomatematika; Pembelajaran Mendalam; Pembelajaran Penemuan; Teorema Pythagoras; Validitas.



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INTRODUCTION

The Pythagorean Theorem is one of the basic principles in school mathematics that forms the foundation for various advanced geometry topics, trigonometry, and its applications in engineering, architecture, and applied sciences. Understanding the Pythagorean Theorem in depth requires not only procedural skills in using formulas, but also conceptual mastery to understand the relationship between the sides of a right triangle and its application in real-life situations. However, various reports show that students' mastery of this material is still far from ideal. Indonesia's PISA data in 2022 revealed that Indonesia's numeracy score was 67th out of 81 countries with an average score of 366 (Susanto et al., 2024), highlighting students' lack of ability to solve contextual mathematics-based problems, including geometry material.

Students' low understanding of the Pythagorean Theorem cannot be separated from teaching methods that are still too focused on procedures and memorizing formulas. The learning process is often dominated by teachers and does not provide enough opportunities for students to explore concepts independently and relate them to their experiences (Akmalia et al., 2021; Puspita Sari, 2023). This situation results in a superficial understanding of mathematical concepts that is disconnected from the social and cultural context of students. In fact, in the era of 21st-century education, the learning process should encourage the development of critical, reflective, and meaningful thinking skills through a contextual and relevant approach (Harahap et al., 2023). In line with existing education policies, the Merdeka Curriculum emerged as a breakthrough that provides flexibility in learning, but the

integration of local wisdom to strengthen the character of students has not yet been explored in a planned manner (Zainuddin, 2025). Therefore, the integration of local wisdom in learning needs to be designed systematically through the preparation of a structured learning plan.

In theory, lesson plan are a number of tools or media facilities, methods, instructions, and learning guidelines that are systematically designed and attractive (Setiani et al., 2023). In the framework of the teaching model, discovery learning is a learning model that changes the learning process from teacher-centered learning to student-centered learning, so that students learn actively by finding themselves, conducting their own investigations, and developing scientific attitudes (Muhammad et al., 2023). . In line with that, the Deep learning approach is a learning skill that allows students to understand knowledge deeply, utilize what they have learned, and apply it as needed, both during the learning process at school and when applying it in the real world (Prianto et al., 2022). In a broader context, "Ethnomathematics" is often defined as research on the relationship between mathematics (mathematics education) and relevant social and cultural backgrounds, i.e. this research shows "how mathematics is produced, transferred, disseminated, and specialized in diverse cultural systems."Zhang and Zhang (2023) including the concrete use of the Pythagorean Theorem.

In practice, combining these three approaches in the learning process cannot be implemented without a structured plan through the development of a valid learning plan. The validity of the learning plan is the first crucial phase in the process of developing

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learning tools, as it determines the suitability of the material, linguistic aspects, presentation, model integration, and technical elements before they are applied in the classroom. Various previous studies have discussed the validity of teaching modules through the application of certain learning models, as revealed by Saharani & Abadi, (2024) which analyzes the validity of mathematics learning media with a discovery learning model. On the other hand, the development of teaching modules based on ethnomathematics has also been carried out, for example by Latif & Talib, (2021), but has not implemented deep learning methods that highlight the relationship between concepts, reflection, and deep meaning, especially on specific themes such as the Pythagorean Theorem. Therefore, this research brings innovation by combining the Discovery Learning model, Deep Learning approach, and ethnomathematics-based into a single lesson plan. This research also specifically evaluates the validity of lesson plan based on aspects of content feasibility, presentation, language use, integration of the Discovery model with the Deep Learning approach, and technical feasibility.

Following these problems and gaps, this research provides a solution in the form of developing an ethnomathematics-based learning plan for the Pythagorean Theorem material that combines the Discovery Learning model and the Deep Learning approach. The novelty of this research lies in the systematic combination of these three approaches in a structured and contextual learning design, as well as prioritizing validity testing as the first step in developing the tool. Thus, the purpose of this study is to create an ethnomathematics-based learning plan that integrates the Discovery Learning

model and the Deep Learning approach in the Pythagorean Theorem material, with a focus on testing the level of validity based on content feasibility, presentation, language, model integration, and technical compliance.

This research has both theoretical and practical significance. From a theoretical perspective, the results of this study are expected to contribute to the development of literature on innovative teaching modules based on ethnomathematics, as well as reveal the possibility of combining the Discovery Learning model and the Deep Learning approach in mathematics education. From a practical perspective, the designed module can serve as a valid and practical teaching tool for teachers in teaching the concept of the Pythagorean Theorem by combining the Discovery Learning model, Deep Learning approach, and ethnomathematics-based, so that learning is more contextual, meaningful, and relevant to students' lives. In addition, this research also has the potential to support students in understanding mathematical concepts through their cultural approaches, so that the learning process feels closer, reflective, and fun.

METHODS

This research is a research and development (R&D) type. With the development model used referring to the 4D model (Four-D Model), the 4D Model was developed by S. Thiagarajan, Dorothy S. Semmel, and Melvyn I. Semmel in 1974 (Yusuf, 2023). However, this study is limited to the development phase, namely until a learning plan product that meets the validity criteria is successfully obtained. Therefore, the research phase and results described in this article include the define, design, and develop stages.

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The application of the 4D model in this study presents an organized basis for creating the product, and at the develop stage, the focus is directed at the

evaluation process by experts as a sign of the initial validity of the learning module. The research steps are presented in Figure 1.

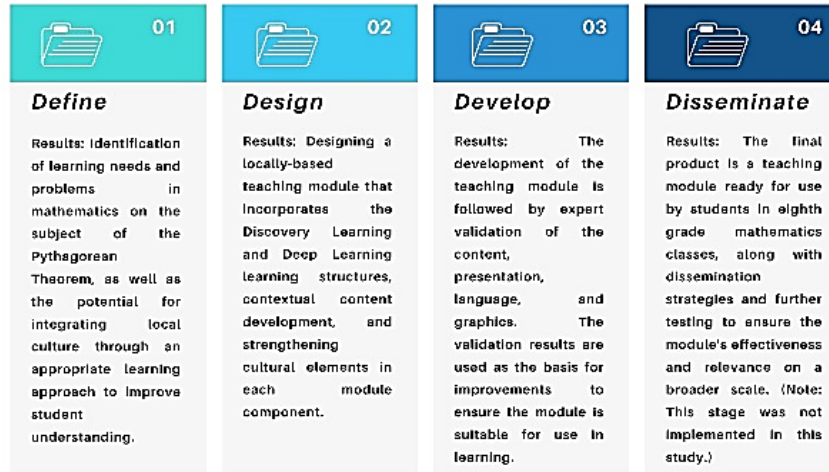


Figure 1. Research flow process

The subjects involved in this study consisted of three experts who served as validators. One of them is a lecturer in mathematics education who focuses on materials and learning design, while the other two are junior high school mathematics teachers who act as expert practitioners. The selection of these three experts was based on their educational background and experience in teaching mathematics, as well as the relevance of the Discovery learning model with the Deep Learning approach. Their validation process included evaluating the appropriateness of the content, presentation, language use, integration of the Discovery model with the Deep Learning approach, and technical feasibility

All learning activities in this lesson plan are designed to deepen students' understanding which is aligned with ethnomathematics. Each section in the module contains contextual questions that help learners discover for themselves the links between concepts through exploring an environment rich

in cultural values. One of the sample problems in this lesson plan uses the Suramadu Bridge as a setting to study the Pythagorean Theorem. The task is formulated to illustrate a right triangle derived from the bridge's support cable structure that links the hypotenuse to the base and height of the bridge.



Figure 2. Display of Local Culture Contextual Task

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The illustration in Figure 2 shows one of the tasks in the lesson plan that is rooted in local culture. In the task, students are directed to observe the shape of a triangle formed by the supporting cables of the Suramadu Bridge, then asked to calculate the length of one side of the triangle using the Pythagorean Theorem. Before the problem is posed, the module presents an introduction in the form of a short narrative about the origin of the bridge, its geographical position, and the cultural significance of the bridge for the people of East Java. In this way, students not only learn math in an abstract form, but also explore cultural values, while gradually developing critical and reflective thinking skills

Table 1. Rating Scale

| Scale | Category |
|-------|---------------------|
| 5 | Very suitable |
| 4 | Suitable |
| 3 | Moderately Suitable |
| 2 | Not Suitable |
| 1 | Very Unsuitable |

The instrument used in this study is a learning device validation sheet designed using a five-point Likert scale, listed in table 1, for each indicator in five main aspects, namely aspects of content feasibility, presentation, language use, integration of the Discovery model with the

Deep Learning approach, and technical feasibility. The data collection process was carried out by submitting the teaching module document and validation sheet directly to the validator. Furthermore, the assessors evaluated the instrument items based on the indicators listed in the validation sheet (Nurjanah et al., 2023). Then they were asked to rate each indicator using a scale of 1 to 5 and provide comments or suggestions

in the column provided. The assessment carried out on each indicator in the validation sheet is to measure the extent to which the teaching module meets the expected standards as an innovative learning material with the Discovery Learning model and Deep Learning approach combined with ethnomathematics

The data obtained from the validation were analyzed using Aiken's V coefficient formula to evaluate the level of agreement among experts regarding each indicator in the validation sheet. The Aiken's V formula applied is as follows (Aiken, 1985):

$$V = \frac{\sum s}{n(c-1)} \dots(1)$$

with information:

s = r - l = the score given minus the lowest score on the scale

r = score given by the validator

l = lowest score on the scale (i.e. 1)

c = number of categories on the rating scale (i.e. 5)

n = number of validators

The V value is in the range between 0 to 1. The higher the Aiken's V value, the more valid the item is. The minimum validity value is set based on a threshold at a certain level of significance, and the results of Aiken's analysis are used as a basis for determining the feasibility of teaching modules. There is also a validity category in this study, which can be found in table 2.

Table 2. Validity Categories

| Aiken's V scale | Validity |
|-----------------|--------------------|
| 0.8 < V | Very High Validity |
| 0.6 < V ≤ 0.79 | High Validity |
| 0.4 < V ≤ 0.59 | Medium Validity |
| 0.2 < V ≤ 0.39 | Low Validity |
| V ≤ 0.19 | Very Low Validity |

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RESULTS AND DISCUSSION

Ethnomathematics-based learning tools using the Discovery model with a Deep Learning approach are created in a module format that contains exploratory and reflective activities on the Pythagorean Theorem. This module is designed by combining the local cultural context as a basis for building mathematical concepts.

| Kegiatan Iniri | |
|---|--|
| <p>Phase 1: Stimulasi/ pemberian rangsaangan</p> | <p>1. Guru menyajikan gambar jembatan tepaujangan di Indonesia yaitu jembatan Surawadu dan peserta didik mengamati gambar yang ditampilkan. <i>(Mindful Learning)</i> (Lampiran 2. Gambar).</p> <p>2. Peserta didik diajak untuk mengidentifikasi dengan mengamati gambar lebih detail lagi. Misalnya, guru bertanya kepada peserta didik:</p> <p>a. Apa pendapatmu tentang jembatan ini? Apakah kamu telah mendengar tentang Jembatan Surawadu sebelumnya? Di lokasi manau jembatan ini berada?</p> <p>b. Perhatikan elemen-elemen dari konstruksi jembatan ini, terutama tiang dan kabel-kabel yang ada. Apa aspek menarik dari bentuk atau pengaturan kabel tersebut?</p> <p>c. Jika kamu jika kamu melihat lebih teliti, seperti apa rupa kabel-kabel yang mendukung jembatan ini? Apakah ada segitiga yang terlihat di sana?</p> |
| | 50 menit |

Figure 3. Stimulation activities in modules focusing on ethnomathematics.

Figure 3 shows the initial phase of the activity (stimulation) in which students are asked to observe local architecture that has right-angled triangle elements as the background to the problem. This activity is designed to encourage students to discover concepts independently before they receive a formal explanation of the Pythagorean Theorem. The module development process follows the 4D model, which includes the Define, Design, and Develop stages.

Define (D1)

The define stage is the first step in developing ethnomathematics-focused lesson plan with the aim of thoroughly identifying learning needs. In this phase, an evaluation of basic competencies, student characteristics, and the relationship between local culture and

mathematics learning, especially on the topic of the Pythagorean Theorem, is carried out. The needs assessment was conducted through reviewing curriculum documents and literature review related to meaningful and contextualized learning. Findings from the analysis show that, Most students feel that abstract mathematical concepts, such as the Pythagorean Theorem, are easier to understand if presented in visual form (Ardhiansah et al., 2025).

To overcome these problems, learning the Discovery Learning model with a deep learning approach can encourage active discovery. And this learning strategy instills the quality of critical thinking in students (Nusantari Elya et al., 2021). In addition, the use of the ethnomathematics approach in teaching mathematics in schools is more accepted and enjoyable in the learning process; in addition, mathematical concepts will be easier to understand (Mania & Alam, 2021). The result of this determination stage is to produce the formulation of learning objectives, with the arrangement of ethnomathematics-based material flow, and the selection of discovery learning model strategies with a deep learning approach as the basis for developing lesson plan that are more contextual, reflective, and responsive to student needs.

Design (D2)

The designed lesson plan focuses on the combination of the Discovery model with an ethnomathematics-based Deep Learning approach, focused specifically on teaching the Pythagorean Theorem at the junior high school level. The local cultural elements integrated include traditional houses and regional bridge patterns that have elements of right triangles. This context serves as a link in building understanding of mathematical concepts in an exploratory

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and reflective way. To create an atmosphere that is close to students' lives in the learning process, with the hope of increasing students' learning motivation in mathematics subjects, one way that can be done is to involve the culture where students live (Firdaus & Nasution, 2023).

Develop (D3)

This stage was carried out through a validation process by subject matter experts and learning experts using a validation sheet that had been prepared. The results of the content validity analysis show that the teaching plan

received a high V Aiken score in each assessment dimension. Through the evaluation of three validators, various aspects such as evaluating content suitability, presentation, language use, integration of the Discovery model with the Deep Learning approach, and technical feasibility showed V values in the high range. According to Aiken, (1985) explanation, a V score close to 1.00 indicates a higher level of validity. Based on this standard, the score obtained indicates consistency in the assessment between validators regarding the developed teaching plan.

Table 3. Table of validity of content feasibility aspects

| Aspects | Aspect number | Aiken V index | Description |
|--------------------------------|---------------|---------------|------------------|
| Aspects of content feasibility | Aspect 1 | 0.92 | Very high |
| | Aspect 2 | 0.92 | Very High |
| | Aspect 3 | 0.92 | Very High |
| | Aspect 4 | 0.75 | High |
| | Aspect 5 | 0.92 | Very High |
| | Aspect 6 | 0.75 | High |
| | Aspect 7 | 0.83 | Very High |
| | Aspect 8 | 0.75 | High |
| Results | | 0.84 | Very High |

In the aspect of content feasibility found in table 3, there are eight indicators that have Aiken V values between 0.75 and 0.92. Five indicators obtained the value $0.83 \leq$ classification is "very high", while the other three indicators fall into the "high" category with a value of 0.75. So the overall result on the content feasibility aspect scored 0.84 with a classification of

"very high". This shows that the content of the lesson plan has met the criteria of material adequacy, relevance to basic competencies, and suitability to the local cultural context raised. Based on the results of the identification of local wisdom, the community service team to design learning modules that integrate these local values into the math and science curriculum (Harefa, 2024).

Table 4. Table of validity of presentation aspects

| Aspects | Aspect number | Aiken V index | Description |
|----------------------|---------------|---------------|------------------|
| Presentation aspects | Aspect 1 | 0.92 | Very High |
| | Aspect 2 | 0.83 | Very High |
| | Aspect 3 | 0.83 | Very High |
| | Aspect 4 | 0.75 | High |
| Results | | 0.83 | Very High |

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In the presentation aspect validation table in Table 4, all indicators received Aiken V scores ranging from 0.75 to 0.92. Three of the four indicators scored $0.83 \leq$ so that it fell into the “very high” group, while one indicator scored 0.75 in the “high” group. So that the overall result on the aspect of presentation gets a score of 0.83 with a classification of “very high”. This shows that the presentation system

in the lesson plan has been arranged in a logical, systematic way, and is able to guide students in learning gradually. This result is in line with the opinion of Gutiérrez et al. (2022), Good presentation is Discovery-based learning has proven to be very effective in science education however, it can be stressful for students if they do not have the necessary guidance and training to build knowledge independently.

Table 5. Table of validity of language use aspects

| Aspects | Aspect number | Aiken V Index | Description |
|-----------------------|---------------|---------------|------------------|
| Language use aspects, | Aspect 1 | 0.83 | Very High |
| | Aspect 2 | 0.75 | High |
| | Aspect 3 | 0.75 | High |
| | Aspect 4 | 0.92 | Very High |
| Results | | 0.81 | Very High |

In the validity of the language use aspect in Table 5, all indicators received Aiken V scores ranging from 0.75 to 0.92. Two of the four indicators scored $0.83 \leq$ so that they fell into the "very high" group, while two indicators scored 0.75 in the "high" group. So that the overall result on the aspect of language use scored 0.81 with a classification of "very high". This indicates that the module uses

communicative language, in accordance with the stage of student development, and can connect formal mathematical concepts with the local cultural context. This result is in line with the opinion of Berlin et al., (2022) The use of appropriate language is very important in making modules, because it supports the process of reflection and understanding of concepts by students.

Table 6. Table of validity of aspects of the integration of the Discovery model with the Deep Learning approach

| Aspects | Aspect number | Aiken V Index | Description |
|---|---------------|---------------|------------------|
| Aspects of the integration of the Discovery model with the Deep Learning approach | Aspect 1 | 0.92 | Very High |
| | Aspect 2 | 0.83 | Very High |
| | Aspect 3 | 0.92 | Very High |
| | Aspect 4 | 0.83 | Very High |
| Results | | 0.87 | Very High |

In Table 6 regarding the validity of the integration aspect of the discovery model with the deep learning approach, all indicators are in the “very high” category with Aiken V index values varying from 0.83 to 0.92. This

shows that the lesson plan successfully accommodates the exploration, formulation, proof and reflection activities. The lesson plan not only guide students in discovering the concept of the Pythagorean Theorem

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via observation of local cultural patterns, but also encourage them to reflect on the meaning of mathematics in everyday life. This learning model is

considered very suitable for creating meaningful learning, encouraging deeper conceptual understanding (Muhammad & Juandi, 2023).

Table 7. Technical feasibility aspects

| Aspects of | Aspect number | Aiken V Index | Description |
|--|---------------|---------------|------------------|
| Table of validity of technical feasibility aspects | Aspect 1 | 0.83 | Very High |
| | Aspect 2 | 1 | Very High |
| | Aspect 3 | 0.75 | High |
| | Aspect 4 | 0.83 | Very High |
| Results | | 0.85 | Very High |

Meanwhile, from the validity of the technical feasibility aspect in table 7, three of the four indicators scored $0.83 \leq$ so that they fell into the "very high" group, while one indicator scored 0.75 in the "high" group. So that the overall result on the aspect of language use scored 0.85 with a classification of "very high". This indicates that visually and technically, this lesson plan has met the eligibility standards related to design, cultural illustrations, readability, and format consistency. well-designed tools and lesson plans can improve student achievement (Najib et al., 2022).

Overall, the average Aiken V index score in all aspects exceeded 0.80, indicating that the lesson plans developed had a very good level of validity. This validity can be understood logically through the integration of ethnomathematics, Discovery Learning steps, and the Deep Learning approach, which created an organized learning flow and encouraged exploration and conceptual thinking. The main findings of this study indicate that the strength of the toolkit depends not only on the completeness of its components, but also on the depth of pedagogical and conceptual integration between various learning elements. Thus, the high validity reflects the suitability of the

design, which significantly supports the understanding of the Pythagorean Theorem concept in a relevant context.

These results were influenced by the alignment between objectives, activities, and assessments, the use of significant cultural contexts, and the design of activities that supported the gradual formation of knowledge. The strengths of this study lie in its systematically validated tools and strong internal consistency, although the number of validators is still limited and has not been tested in various contexts, so its external validity needs to be improved. These findings are in line with Supriyadi et al., (2024) and Fatra et al., (2025), who emphasize the importance of a local culture-based and reflective approach in mathematics learning, but this study expands on this by integrating deep discovery-based learning. Implicitly, these results contribute to the development of a more contextual, reflective, and practical mathematics lesson plan design that is ready for practical testing and effectiveness evaluation.

CONCLUSIONS AND SUGGESTIONS

This study reveals that the ethnomathematics-based learning plan through the Discovery approach in the

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Deep Learning model is declared highly valid based on expert evaluation. This validity covers aspects of content feasibility, delivery methods, language use, integration of Discovery Learning syntax with the Deep Learning approach, and technical feasibility. Overall, the developed lesson plan meets the validity criteria in terms of content, methods, and visuals, making it an innovative choice in learning to enhance conceptual understanding and strengthen appreciation of local culture in mathematics teaching.

Based on the results of this study, it is recommended that future research evaluate the effectiveness of this learning plan through direct implementation in the classroom to obtain empirical data on its impact on learning outcomes, reflective thinking skills, and student participation. In addition, similar developments can be applied to other mathematics topics and at different levels of education to expand the contribution of ethnomathematics-based learning models with a reflective approach.

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