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VALIDITY OF ETHNOMATHEMATICS-BASED LESSON PLANS: A DEEP LEARNING APPROACH TO THE PYTHAGOREAN THEOREM

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Abstract

The lack of lesson plan that integrate local culture and encourage students to learn reflectively posed a challenge in creating meaningful and contextual mathematics learning experiences. 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. The module successfully linked mathematical concepts with local culture, presented an organized and communicative learning structure, and effectively encouraged student exploration and reflection. These findings confirmed that this lesson plan is suitable for application in contextual mathematics education. 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. 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; Ethnomathematics; Pythagorean Theorem; Validity.

Abstrak

Kurangnya perangkat pembelajran yang menggabungkan dengan budaya setempat dan mendorong siswa untuk belajar secara reflektif menjadi tantangan dalam menciptakan pengalaman belajar matematika yang bermakna dan kontekstual. 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. Modul 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 matematika 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. 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; Teorema Pythagoras; Validitas.*

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INTRODUCTION

Education in the 21st century requires changes in learning methods that are not only focused on mastering material, but also on improving critical thinking skills and strengthening character through relevant and meaningful approaches. In this case, education and culture cannot stand alone, so basically, education is a single entity that relates to other entities according to the prevailing era and context (Harahap et al., 2023). The Merdeka Curriculum emerged as an educational innovation that offers a flexible learning approach, but the integration of local wisdom in strengthening student character has not been systematically explored (Zainuddin, 2025). The hope of this approach is to produce learning that is not only efficient in academic aspects, but also able to empower students socially and culturally to face future challenges.

In practice, mathematics education still encounters many obstacles, especially related to the method and relevance of the material taught. Hasil PISA Indonesia tahun 2022 Pada bidang numerasi, menempati posisi ke 67 dari 81 negara dengan skor 366 (Susanto et al., 2024). Until now, math is still considered a difficult, boring, and scary subject. This assumption is caused by students' lack of understanding of mathematics material (Akmalia et al., 2021). In learning mathematics, mathematical understanding is an important factor in understanding the material taught to students, because this is not just memorizing theory, but understanding the material taught (Puspita Sari, 2023), one of which is the pytagorean theorem. Teaching methods that only focus on memorization and are dominated by teachers without contextual concepts further widen the gap between students and the true meaning of mathematics. In fact, local culture holds great potential as a source of contextual learning, where various elements, patterns, and shapes of traditional buildings, ornaments, and handicrafts can be explained with a mathematical approach, including the real and meaningful application of the Pythagorean Theorem concept.

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 & Zhang, 2023)

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including the concrete use of the Pythagorean Theorem.

The validity of lesson plan is an important aspect that reflects the quality of content, language, and presentation, so that it can contribute to a valuable learning experience for students. 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 ethnomathematicsbased 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.

Based on the background and theoretical studies that have been described, the research question is what is the validity level of lesson plan that focus on ethnomathematics by applying the Discovery Learning method and the Deep Learning approach to the Pythagorean Theorem material? In line with this question, the purpose of this study is to analyze the validity of lesson plan that incorporate ethnomathematics, use the Discovery Learning model, and apply the Deep Learning approach to support learning of the Pythagorean Theorem that is relevant, contextual, and in accordance with the characteristics and needs of students.

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 ethnomathematicsbased, 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 using 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). The first stage is Define or often referred to as the needs analysis stage, and the second stage is Design, which is preparing the conceptual framework of learning models and tools, then the third stage is Develop, which is this development stage involving validation testing or media feasibility assessment, and the last

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stage is Disseminate, which is implementation on the targeted research subjects (Maydiantoro, 2021). However, this research only focuses on the develop step, as a crucial stage to determine the level of validity of learning devices before further trials are conducted. 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.

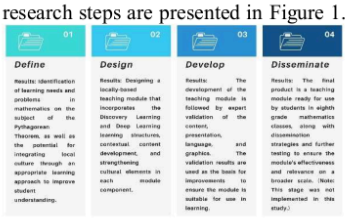

Figure 1. Research flow process

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

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

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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):

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

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
$0{,}6 < V \leq 0{,}79$	High Validity
$0{,}4 < V \leq 0{,}59$	Medium Validity
$0{,}2 < V \leq 0{,}39$	Low Validity
$V \leq 0{,}19$	Very Low Validity

RESULTS AND DISCUSSION

Define Learning Device

The define stage is the first step in developing ethnomathematics-

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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.

Preliminary Design of Learning Devices

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 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).

Content Validity of Lesson Plan

The validity assessment stage of lesson plan is held to ensure that the lesson plan developed meet the eligibility criteria both from the aspects of content feasibility, presentation, language use, integration of the Discovery model with the Deep Learning approach, and technical feasibility from experts. The learning module created, based on ethnomathematics, and combining the Discovery Learning model and Deep Learning approach in teaching the Pythagorean Theorem, was verified by three validators, and analyzed using Aiken's V formula.

The purpose of the assessment is to assess how well the lesson plan meets content appropriateness in depth and logically. Expert agreement is stronger when Aiken's V value is closer to 1.00, indicating high validity; conversely, values closer to 0.00 indicate lower validity (Aiken, 1985).

Table 3. Table of validity of content feasibility aspects

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Aspects	Aspect number	Aiken V index	Description
Aspects of content feasibility	Aspect 1	0,916667	Very high
	Aspect 2	0,916667	Very High
	Aspect 3	0,916667	Very High
	Aspect 4	0,75	High
	Aspect 5	0,916667	Very High
	Aspect 6	0,75	High
	Aspect 7	0,833333	Very High
	Aspect 8	0,75	High
	Results	0,84375	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 0.916. Five indicators obtained the value 0,83 ≤ 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	0,916667	Very High
	Aspect 2	0,833333	Very High
	Aspect 3	0,833333	Very High
	Aspect 4	0,75	High
	Results	0,833333	Very High

In the presentation aspect validation table in Table 4, all indicators received Aiken V scores ranging from 0.75 to 0.916. Three of the four indicators scored0,83 ≤ 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	0,833333	Very High
	Aspect 2	0,75	High

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	Aspect 3	0,75	High
	Aspect 4	0,916667	Very High
	Results	0,8125	Very High

In the validity of the language use aspect in Table 5, all indicators received Aiken V scores ranging from 0.75 to 0.916. Two of the four indicators scored0,83 ≤ 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	0,916667	Very High
	Aspect 2	0,833333	Very High
	Aspect 3	0,916667	Very High
	Aspect 4	0,833333	Very High
	Results	0,875	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 0.833 to 0.916. 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 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	0,833331	Very High
	Aspect 2	1	Very High
	Aspect 3	0,75	High
	Aspect 4	0,833333	Very High
	Results	0,854167	Very High

Meanwhile, from the validity of the technical feasibility aspect in table 7, three of the four indicators scored0,83 ≤ 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

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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 of all aspects is above 0.80 which indicates that this lesson plan is very valid to use. The high level of validity in all aspects indicates that the lesson plan is qualified as an effective, communicative, and relevant lesson plan. This success supports the findings of(Supriyadi et al., 2024) which states that the use of lesson plan that refer to local culture with a reflective and explorative approach can improve the quality of students' mathematics learning processes and outcomes, especially in terms of concept understanding and problem solving.

CONCLUSIONS AND SUGGESTIONS

This study concluded that the lesson plan based on ethnomathematics through Discovery learning model with Deep learning approach. This validity is reflected in five elements evaluated by experts, ranging from aspects of content feasibility, presentation, language use, integration of the Discovery model with the Deep Learning approach, and technical feasibility. In the content feasibility aspect, this lesson plan is proven to present material that is in line with the learning objectives and successfully combines local cultural elements in a contextual and meaningful way. The presentation aspect reflects that the lesson plan have been organized systematically and logically, making it easier for students to follow the concept thinking process. With regard to language, the lesson plan use terms that are communicative, clear, and in accordance with students' cognitive development level. Furthermore, in terms of learning approach, the lesson plan show full implementation of the syntax of Discovery Learning and include reflective elements of Deep Learning that support students in understanding the concepts better. Finally, on the technical aspect, the lesson plan have met the visual standards, readability, and consistency of display, thus encouraging students' active engagement during the learning process.

The findings as a whole provide answers to the research questions that the lesson plan designed are highly valid in terms of content, method, and appearance, so they deserve to be an alternative innovative lesson plan that can improve conceptual understanding while fostering a sense of appreciation for local culture in mathematics learning.

Based on the evaluation results that illustrate the very high quality of this lesson plan, it is recommended that the lesson plan be further tested in classroom practice to collect empirical data related to its effectiveness on student learning outcomes. Similar development can also be done on other mathematics materials by considering the integration of local culture and reflective learning approaches, to expand contextual learning innovations that are meaningful and relevant to students' lives.

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