Innovation of Ethnomathematics-Based Digital Teaching Materials to Enhance Junior High School Students' Mathematical Problem-Solving Skills

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***Abstract*-** This study aims to develop digital teaching materials based on ethnomathematics to enhance the geometry problem-solving abilities of eighth-grade students at SMP Negeri 1 Kota Bima. Using the Research and Development (R&D) 4D model by Thiagarajan, Semmel, and Semmel 1974, this study underwent four stages: Define, Design, Development, and Disseminate. In the Define stage, the analysis identified that 50% of students faced difficulties in geometry. The Design stage resulted in a prototype e-module that integrates the local culture of Bima. During the Development stage, the teaching materials were validated, showing that the Lesson Plans (RPP) and Student Worksheets (LKS) required revisions, while the Syllabus was deemed excellent. The trials indicated a significant improvement in students' problem-solving abilities and a positive response to the cultural relevance in the teaching materials. The results of this study support the effectiveness of digital teaching materials based on ethnomathematics and recommend their broader application in the context of mathematics education.

***Index Terms*-** Digital Teaching Materials; Ethnomathematics; Geometry; Problem solving skill; 4D Models.

I. INTRODUCTION

One way to train students' holistic abilities is through mathematics education. Mastery of mathematics has become crucial in this era of globalization. Mathematics provides a solid foundation for understanding scientific concepts and modern technology (Weng, 2017; Semenov et al., 2023). By understanding mathematical principles, students can more easily master the ever-evolving science and technology, making them better prepared to adapt to changes over time (Cardona et al., 2023). Therefore, it is important for the education system to give sufficient attention to the development of students' mathematical skills (Oco et al., 2023). This not only means strengthening the mathematics curriculum but also ensuring that effective teaching methods are used to help students understand and apply mathematical concepts in everyday life and various scientific and technological contexts (Dwirahayu et al., 2022).

Currently, SMP Negeri 1 Kota Bima has implemented the independent curriculum in its learning process, where teachers are required to produce teaching materials using digital technology to maximize the learning process (Fauzan et al., 2023).

Based on field observations conducted in the eighth grade at SMP Negeri 1 Kota Bima, several challenges were identified that most students face in developing problem-solving skills in geometry. Despite having basic knowledge, students still struggle to apply appropriate strategies in solving problems. This is indicated by the fact that many teachers still tend to rely on conventional teaching materials. Out of 30 students in the eighth grade at SMP Negeri 1 Kota Bima, 50% or half of them are still below the Minimum Competency Criteria (KKM). This issue is related to the limited teaching materials at the school, which only rely on school books. Cartono, (2022) explains that while conventional teaching materials remain important, integration with more dynamic media and learning resources can provide a more engaging and diverse learning experience for students (Shabiralyani et al., 2015).

Concrete steps are needed to update the learning approach, including the development of digital teaching materials that integrate local culture, particularly the Bima region. The application of ethnomathematics in mathematics education, especially in geometry, provides an important new dimension in the educational process (Cartono, 2022). In this context, geometry is not only presented as a series of abstract concepts but is also enriched with cultural values relevant to students (Sudarsono et al., 2023). By introducing examples such as the structure of traditional houses or even traditional games (Wulansari & Dwiyanti, 2021; Kancanadana et al., 2021), mathematics learning becomes more interesting and meaningful for students as it closely connects with their cultural reality (Uyen et al., 2021). Ethnomathematics not only acknowledges the diversity in how communities apply mathematics in their daily lives (Anggraini et al., 2022) but also strengthens the close relationship between mathematics and culture (Hariastuti et al., 2022).

By integrating ethnomathematics principles into the learning process, teachers can help students see that the mathematical concepts they learn are not isolated from everyday life (Rosa & Orey, 2016), but are directly connected to their own cultural context (Kancanadana et al., 2021). In such a learning environment, students' understanding of geometry becomes deeper and more applicable (Kancanadana et al., 2021).

This study finds close relevance with several previous studies. First, the research conducted by Sutarto et al. (2023) on "Ethnomathematics-based E-Module Development for Improving Conjecturing Ability in Object Configuration Materials." This research emphasizes students' activities to understand problem-solving through conjecturing, which often has relevance to local culture, thereby expanding their understanding of mathematics in a broader context. Next, the research conducted by Agustina Babe et al. (2023) titled

"Development of an Ethnomathematics-Based E-Module with a focus on improving students' mathematical communication skills." This research emphasizes students' activities to articulate their mathematical thinking clearly and effectively to others, which is an important skill in mathematics learning.

This study brings significant differences and novelty. Specifically, it refers to the Development of Ethnomathematics-Based Digital Teaching Materials, which links geometry learning with local wisdom, particularly in Bima culture, such as the motifs of *tembe nggoli* woven fabrics, the structure of *uma lengge* traditional houses, and the traditional game of *mpaa gopa*, which relies on geometric strategies. This research focuses on enhancing problem-solving skills in geometry (shapes and spaces) for eighth-grade students at SMP Negeri 1 Kota Bima. With an approach that integrates local cultural aspects into mathematics learning, this study is expected to make a meaningful contribution to the field of mathematics education and culture-based learning.

Based on the above issues, this study focuses on the question: How effective is ethnomathematics-based digital teaching material in enhancing problem-solving skills in geometry for eighth-grade students at SMP Negeri 1 Kota Bima?

II. METHODS

This study was conducted at SMP Negeri 1 Kota Bima with 30 eighth-grade students as the research subjects, using the Research and Development (R&D) 4D model by Thiagarajan, Semmel, and Semmel (1974). The research process consists of four main stages (Gorbi Irawan et al., 2018):

1. Define**:** In this stage, the objectives, teaching materials, and teaching requirements are established. An analysis of student characteristics and geometry material is conducted to identify students' comprehension difficulties.
2. Design**:** In this stage, a prototype of ethnomathematics-based digital teaching material is developed, with the expected outcome being a prototype ready for trial.
3. Development**:** In this stage, the digital teaching material is further developed and validated, then tested on a small and large scale to ensure effectiveness and revise based on feedback.
4. Disseminate**:** In this stage, the digital teaching material is disseminated to schools and teachers for use in the learning process.

The research instruments include validation sheets (Lesson Plans, syllabus, e-modules, Student Worksheets, and test questions), Student Worksheets for collecting data on activities during trials, and test questions to measure students' mathematical problem-solving abilities in geometry (Rosa & Orey, 2016). Data analysis techniques include validation of teaching materials based on average scores, trial analysis covering teacher performance, student activities, student responses, and learning outcome tests, with emphasis on the validity, sensitivity, and reliability of the tests (Rice & Ortiz, 2021).

III. RESULT

A. Define

Based on observations and initial tests, approximately 50% of students experience difficulties in understanding and applying mathematical problem-solving concepts in geometry. After the implementation of ethnomathematics-based digital teaching materials, it is expected that at least 80% of students will be able to understand and apply these concepts effectively.

Analysis of student characteristics shows that the majority have a basic understanding of geometry but struggle to apply the concepts to problem-solving. They need interactive and contextual teaching materials that link mathematical concepts with local culture to make learning more engaging and meaningful. The geometry learning materials cover basic concepts such as plane and solid shapes, focusing on form, size, and spatial relationships, relevant to the SMP Negeri 1 Kota Bima curriculum.

Concept analysis highlights key elements such as surface area and volume of solid shapes, properties of plane figures, and the relationship between geometric shapes and real-life applications. The learning objectives are for students to understand basic geometric concepts, apply them to solve real-world problems, connect concepts with Bima's local culture such as the *uma lengge* traditional house structure and *tembe nggoli* woven fabric motifs, traditional game patterns, and others, as well as improve their mathematical problem-solving skills.

It was found that around 50% of eighth-grade students at SMP Negeri 1 Kota Bima failed to grasp mathematical problem-solving concepts in solids and plane figures. This underscores the need for developing ethnomathematics-based digital teaching materials to help students overcome these difficulties, providing a strong foundation for continuing this research.

B. Desing

The design of the ethnomathematics-based digital teaching module in the form of an Android application aims to integrate geometric mathematical concepts with the local culture of the Mbojo community. This module is designed for eighth-grade students and utilizes elements of local culture, such as the traditional *Uma Lengge* house, traditional musical instruments, traditional games, and *Tembe Nggoli* weaving.

The application presents learning materials through the exploration of local culture related to geometric concepts, such as the cone shape of the *Uma Lengge* traditional house to teach volume and surface area, and the geometric patterns on *Tembe Nggoli* weaving to study symmetry and geometric transformations. Traditional games like *Mpa'a Gopa* are also used to provide practical experiences in recognizing geometric shapes.

By linking mathematical concepts to students' everyday lives, this module is expected to enhance their understanding of geometry, problem-solving skills, and preserve local cultural values. This approach is also designed to make learning more engaging and relevant, thereby increasing students' motivation and active participation in the learning process.

Figure 1. Local Bima cultural elements

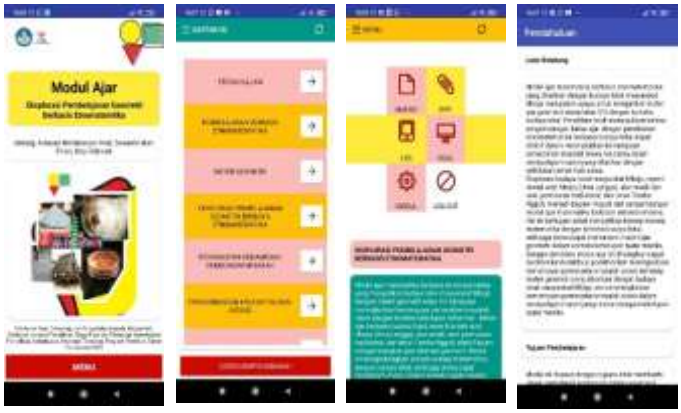

Figure 2. APP Teaching Module

C. Development

1. Validity of Learning Tools

The results of the validation data analysis in Table 1 show that various components of the teaching materials have different validity categories. The Lesson Plans (RPP) with an average score of 2.75 fall into the good category and require revisions to reach the very good category. The e-Module (3.45) and test questions (3.20) also fall into the good category and need slight revisions to be elevated to the very good category. Conversely, the Syllabus with an average score of 3.60 is already in the very good category and is considered valid without significant improvements. The Student Worksheets (LKS) with an average score of 2.85 also fall into the good category and require some improvements.

Based on the validity category, learning tools are considered valid if they fall into the good or very good categories. The analysis results showing the good category will be used as a basis for further revisions to improve their quality. Thus, revision efforts are expected to address shortcomings and achieve the very good standard, making the teaching materials more effective in supporting the student learning process.

Tabel 1. Validity of Learning Tools

Validation Component	Validity Category	Average Score	Description
Lesson Plan (RPP)	2,75	Good	Requires revision to reach the very good category
Syllabus (SILABUS)	3,60	Very Good	Valid, meets the expected criteria
E-Module	3,45	Good	Requires minor revision to reach the very good category
Student Worksheet (LKS)	2,85	Good	Valid, but requires some improvements
Test Questions	3,20	Good	Requires minor revision to reach the very good category

1. Teachers' Ability to Manage Learning

The analysis of data on teachers' ability to manage learning (Table 2) shows varied results. Lesson preparation received an average score of 3.40, falling into the good category, though there is still room for improvement. The management of learning activities was rated very good with a score of 3.60, indicating high effectiveness in organizing classroom activities. The adaptation of teaching strategies, with a score of 3.20, also falls into the good category, but needs slight improvement to reach very good. Evaluation and follow-up received a score of 2.90, showing that this aspect needs more attention to achieve the very good category. Interaction with students was rated very good with a score of 3.50, indicating effective and supportive interaction between teachers and students. Overall, the teachers' abilities range from good to very good, with some areas needing improvement to reach excellence.

Table 2: Analysis of Teachers' Ability to Manage Learning

Assessment Aspect	Average Score	Ability Category	Description
Learning Preparation	3.40	Good	Meets the good criteria, but there is room for improvement
Management of Learning Activities	3.60	Very Good	Meets the very good criteria, effective in activity management
Adjustment of Learning Strategies	3.20	Good	Valid, requires minor improvement to reach the very good category

Evaluation and Follow-up	2.90	Good	Needs more attention to reach the very good category
Interaction with Students	3.50	Very Good	Meets the very good criteria, effective interaction

2. *Student Responses*

A trial was conducted with 30 students from class VIII of SMP Negeri 1 Kota Bima (Table 3), which provided data on the effectiveness of the teaching materials in enhancing problem-solving skills. Based on feedback from the trial, the teaching materials were revised to improve the clarity of the content and cultural relevance. The results of the revision indicate that the teaching materials are now better suited to the students' needs and more effective in enhancing their understanding of geometry.

Table 3: Analysis of Student Responses to Ethnomathematics-Based Digital Teaching Materials

Student Response Aspect	Number of Positive Responses	Number of Students	Percentage (%)	Category
Suitability of teaching materials with the content	24	30	80%	Positive
Student engagement in learning	20	30	75%	Positive
Ease of use of teaching materials	27	30	90%	Positive
Suitability of allocated time with activities	21	30	67%	Negative
Increased learning motivation	18	30	70%	Positive

3. Analysis of Student Activities

The analysis of student activities data shows variations in the alignment between the time used and the ideal time for various activities. Discussion activities, which occurred 45 times (30%), aligned with the ideal time of 15 minutes, using 14 minutes, thus falling within the 10% tolerance limit. Practical activities, with the highest frequency of 60 times (40%), also aligned with the ideal time of 20 minutes, using 22 minutes, which is still within the tolerance limit. Individual assignment activities, occurring 30 times (20%), matched the ideal time of 15 minutes, using 15 minutes, also within the tolerance limit. However, question-and-answer activities, occurring 15 times (10%), did not align with the ideal time of 5 minutes, using 6 minutes, exceeding the 10% tolerance limit. Overall, the majority of student activities were in accordance with the expected ideal time, except for the question-and-answer activities, which need time adjustment (Table 4).

Tabel 4: Analysis of Student Activity Data

Student Activity Aspect	Frequency (F)	Total Frequency	Percentage (%)	Ideal Time (Minutes)	Time Used (Minutes)	10% Tolerance Range	Suitability
Discussion Activity	45	150	30%	15	14	13.5 - 16.5	Suitable
Practical Activity	60	150	40%	20	22	18 - 22	Suitable
Individual Assignment Activity	30	150	20%	15	15	12 - 16	Suitable
Q&A Activity	15	150	10%	5	6	4.5 - 5.5	Not Suitable

4. Student Satisfaction with Digital Teaching Materials

The analysis of student satisfaction with ethnomathematics-based digital teaching materials shows varied results. Regarding satisfaction with the content, 33.33% of students were satisfied and 30.00% were very satisfied, while 16.67% were very dissatisfied and 6.67% were dissatisfied. Additionally, 13.33% of students were neutral. Satisfaction with the media showed that 40.00% of students were satisfied and 26.67% were very satisfied, with 10.00% very dissatisfied and 6.67% dissatisfied, while 16.67% of students were neutral. For satisfaction with cultural relevance, 33.33% of students were satisfied and 30.00% were very satisfied, while 13.33% were very dissatisfied and 10.00% were dissatisfied, with 13.33% being neutral. Overall, the majority of students responded positively to the teaching materials in terms of content, media, and cultural relevance (Table 5).

Table 5. Student Satisfaction with Ethnomathematics-Based Digital Teaching Materials

Assessment Aspect	Number of Respondents	Percentage of Positive Responses (%)
Satisfaction with Content		
Very Dissatisfied	5	16.67%
Dissatisfied	2	6.67%
Neutral	4	13.33%
atisfied	10	33.33%
Very Satisfied	9	30.00%
Satisfaction with Media		
Very Dissatisfied	3	10.00%
Dissatisfied	2	6.67%
Neutral	5	16.67%
Satisfied	12	40.00%
Very Satisfied	8	26.67%
Satisfaction with Cultural Relevance		
Very Dissatisfied	4	13.33%
Dissatisfied	3	10.00%
Neutral	4	13.33%
Satisfied	10	33.33%
Very Satisfied	9	30.00%

well. This value falls within the acceptable range for a reliable

Table 7. Test Item Sensitivity Analysis

Test Item	Average Score of Upper Group	Average Score of Lower Group	Maximum Score	Sensitivity	Description
1	4.5	2.0	5	0.50	Sensitive item, distinguishes well between upper and lower groups
2	4.0	2.5	5	0.30	Fairly sensitive item
3	4.8	1.8	5	0.60	Very sensitive item
4	4.2	2.4	5	0.36	Fairly sensitive item
5	4.6	2.2	5	0.48	Sensitive item
6	4.7	2.1	5	0.52	Sensitive item
7	4.3	2.7	5	0.32	Fairly sensitive item
8	4.1	2.3	5	0.36	Fairly sensitive item
9	4.9	1.9	5	0.60	Very sensitive item
10	4.4	2.0	5	0.48	Sensitive item

5. *Item Validity*

The results of this study indicate that most test items have a significant correlation with the total test score. For example, test items 1, 2, 4, 5, 7, 8, 9, and 10 have correlation values (r) greater than 0.30, indicating that these items are valid and accurately measure students' abilities. However, test items 3 and 6 have correlation values less than 0.30, specifically 0.29 and 0.25, respectively, which means these items are not valid and do not have a strong relationship with the students' total scores (Table 6).

Table 6. Test Item Validity

Test Item	Average Item Score	Total Score	Correlation (r)	Validity
1	3.5	80	0.42	Valid
2	2.8	85	0.35	Valid
3	3.2	75	0.29	Not Valid
4	3.0	85	0.45	Valid
5	2.9	75	0.40	Valid
6	3.1	75	0.25	Not Valid
7	3.6	80	0.50	Valid
8	3.3	80	0.38	Valid
9	2.7	75	0.31	Valid
10	3.4	75	0.48	Valid

6. *Item Sensitivity*

This study analyzed the sensitivity and validity of 10 test items to assess students' abilities in a specific context. The sensitivity analysis results indicate that most test items have a good ability to differentiate between students with high and low abilities. Test items 3 and 9 showed the highest sensitivity with a value of 0.60, indicating that these items are very effective in distinguishing students based on their abilities. Conversely, test items 2 and 7 had lower sensitivity values, 0.30 and 0.32 respectively, but still fall within the sufficiently sensitive category (Table 7).

7. Test Reliability

The Cronbach's Alpha value of 0.702 indicates that the test items in this instrument consistently measure the same construct instrument, suggesting that this test can be trusted to measure students' mathematical problem-solving abilities. Therefore, the results of this analysis indicate that the test items in this study have good internal consistency, and the test instrument can be considered both valid and reliable (Table 8).

Table 8. Test Reliability

Parameter	Value
Total Item Variance	2.8
Total Test Variance	7.6
Cronbach's Alpha	0.702

2. *Disseminate*

The digital ethnomathematics-based module developed in this study shows significant potential in enhancing the effectiveness of mathematics learning in schools. The feasibility of this module can be assessed from several key aspects: validity, reliability, and user acceptance. Validity, which measures the extent to which the module achieves the predetermined learning objectives, indicates that the module content aligns with curriculum standards and expected educational goals. This validation was conducted by experts who assessed the material's suitability with pedagogical criteria and local cultural relevance. Additionally, reliability, measured using Cronbach's Alpha, demonstrates adequate internal consistency, indicating that the module consistently measures students' problem-solving abilities. Overall, these findings suggest that the digital ethnomathematics-based module is both valid and reliable, with the potential for broad acceptance among users, thereby significantly enhancing mathematics education.

In the trial process, the digital module has proven effective in enhancing students' understanding and skills in geometry. Data from the trial results indicate that students using this module experienced a significant improvement in their mathematical problem-solving abilities. Additionally, analysis of the test results confirms that the module positively contributes to students' academic achievement. This success is reflected in higher test scores and positive feedback from both

students and teachers, indicating that the module can be well integrated into classroom learning processes.

The dissemination of this digital module in schools needs to be supported by adequate training and socialization for teachers. Effective adoption of the module will require technical and pedagogical support to ensure optimal use in classroom environments. Therefore, this digital module not only meets the criteria as a valid and reliable teaching material but also offers an innovative approach by incorporating local cultural aspects into mathematics learning, providing a more relevant and contextual learning experience for students.

IV. DISCUSSION

Results of this study indicate that the validity of the learning materials, including Lesson Plans (RPP), e-Modules, test items, syllabus, and Student Worksheets (LKS), ranges from good to very good. The RPP, with a score of 2.75, shows that although it falls into the good category, it still requires revision to achieve the very good category. This aligns with the "Backward Design" principle proposed by McTighe & Wiggins (2012), which emphasizes the importance of a clear and directed learning plan. The e-Modules and test items, with scores of 3.45 and 3.20 respectively, are also in the good category and require slight revisions. The multimedia principles proposed by Clark et al. (2016) and Werdiningsih et al. (2019) suggest that the design of e-Modules should be interactive to maximize learning effectiveness. The syllabus, which received a score of 3.60 and falls into the very good category, reflects alignment with curriculum standards as described by Tyler (in Maria et al., 2004). Meanwhile, the LKS with a score of 2.85 requires some improvements to better support active learning, as recommended by Popham (2009).

In terms of teachers' ability to manage learning, the analysis reveals significant variation across the evaluated aspects. The management of learning activities was rated very good with a score of 3.60, reflecting high effectiveness in classroom organization, consistent with the findings of Marzano & Marzano (2003a) on the importance of effective classroom management for enhancing student learning outcomes (Marzano et al., 2003b). The adjustment of teaching strategies, with a score of 3.20, suggests that teachers need to make further adjustments to meet individual student needs, as described in Tomlinson's (2001) theory of differentiated instruction. Evaluation and follow-up, with a score of 2.90, indicate a need for more attention, supporting Black & Wiliam's (2009) findings on the importance of feedback and follow-up in formative assessment. Interaction with students, rated very good with a score of 3.50, suggests that teachers have successfully created a positive learning environment, aligning with Hattie's (2008) theory on the impact of positive interactions on learning outcomes.

Student responses to the teaching materials show generally positive feedback. The ease of use of the materials, with a 90% approval rate, indicates that students find the materials easy to use and access, consistent with Clark et al.'s (2016) findings on the importance of ease of use in the effectiveness of digital teaching materials. Student engagement, positively rated at 75%, suggests that the materials successfully motivate students, aligning with Keller's (2016) theory on motivational design. However, the negative feedback on the alignment of time allocation with activities indicates a need for adjustment in time management, consistent with Gagne's (1985) recommendations (as cited in Tria Amalia & Suryaningtyas, 2023) on time management in instructional design.

The analysis of student activities reveals that most activities, such as discussions and practice sessions, align well with the ideal time expectations, reflecting effective time management. These findings are consistent with the research of W. Johnson & T. Johnson (2018) and Johnson & Johnson (2014), which emphasize the importance of appropriate timing for collaborative activities. However, the question-and-answer sessions, which exceeded the tolerance limit, indicate a need for further adjustment.

Student satisfaction with the digital teaching materials shows varied results. Satisfaction with the content, media, and cultural relevance indicates that most students responded positively to the materials. This supports Ha et al.'s (2024) findings that relevance of content and quality of media are key factors in student satisfaction. However, some students felt less satisfied with the cultural relevance, suggesting the need for further adjustments to ensure better cultural alignment.

The validity of test items shows that most items are valid, with significant correlations for items 1, 2, 4, 5, 7, 8, 9, and 10. This supports the importance of test item validity in accurately measuring student abilities. However, items 3 and 6, with correlations below 0.30, indicate that improvements are needed.

The sensitivity analysis of test items shows that most items are effective in differentiating between students with high and low abilities, with items 3 and 9 showing the highest sensitivity. This finding supports Crocker & Algina's (2008) theory on item sensitivity as an indicator of test effectiveness in assessing student abilities.

The Cronbach's Alpha value of 0.702 indicates that the test instrument has good internal consistency, supporting the test's reliability in measuring students' mathematical problem-solving abilities. This value aligns with the reliability standards proposed by Cronbach (1951) (as cited in Tavakol & Dennick, 2011), demonstrating that the test can be reliably used for evaluative purposes.

V. CONCLUSION

This study demonstrates that the ethnomathematics-based digital teaching materials are effective in enhancing the understanding of geometry concepts and problem-solving abilities among students of SMP Negeri 1 Kota Bima. The validity and reliability of the teaching tools, including the e-Module and test items, meet adequate standards. While teachers' ability to manage learning is generally good, some aspects require improvement. Student responses indicate positive satisfaction with the ease of use and cultural relevance of the materials, although there is a need for adjustments in the time allocation for activities. The module shows great potential in providing a contextual and effective learning experience, with recommendations for further refinement and additional training support for teachers.

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