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# Development of Ethnomathematics-Based E-LKPD on Solid Geometry

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**Abstract**

In the Society 5.0 era, the world of education demands that teachers possess 21st-century skills, including the ability to use technology and deliver material effectively. However, the use of technology-assisted learning media in schools remains limited, and students often face difficulties in understanding the concept of curved-sided three-dimensional shapes. This study aims to develop an ethnomathematics-based E-LKPD to aid students' understanding of these concepts by integrating culture and technology. The ADDIE model was used for development, with validity, practicality, and effectiveness data measured. Validity data were obtained through expert validation, while practicality and effectiveness data were collected through a pilot test at SMP Al-Rifaie, Malang. The validation rate for subject-matter experts was 92.1% and the validation rate for media experts was 88.3% (Highly Valid), a practicality score of 84% (limited pilot test) and 85.8% (wider pilot test), and effectiveness with a classical mastery rate of 81.2% and a binomial test result (sig. 0.000). These results indicate that ethnomathematics-based E-LKPD is effective in improving students' understanding of curved-sided three-dimensional shapes, as well as increasing student engagement and enthusiasm within the cultural context of the Tiban Mosque.

Keywords: Development; E-LKPD; Ethnomathematics; Curved-Sided Three-Dimensional Shapes

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## 1. Introduction

Education is the most important means of developing and optimizing individual potential, including social and cultural potential (Douara et al., 2026; Samsulbassar et al., 2020) . Education serves as a space for students to uphold national cultural values and forms (Farida et al., 2021; Yulianie et al., 2025) . However, globalization has gradually eroded national cultural values (Fitri et al., 2025) . These cultural values can be clearly seen and are relevant to students in mathematics education (Joly et al., 2026; Maden et al., 2026; Werang et al., 2026) .

Mathematics itself plays a crucial role in daily life, as nearly all human activities are related to mathematics, including cultural practices (Mustafa et al., 2025) . It is this relationship between mathematics and culture that is explored through ethnomathematics. (Manohar, 2026; Palhares, 2025) defines ethnomathematics as mathematics practiced by specific cultural groups, whereas (Santoso et al., 2027; Pantsar, 2021) , through the concept *of mathematical enculturation,* asserts that mathematical knowledge grows from universal human activities such as counting, measuring, determining location, designing, playing, and explaining. Therefore, ethnomathematics should not be understood merely as a teaching approach that incorporates cultural elements into the classroom, but as a theoretical perspective that views mathematics as knowledge that is born, develops, and is passed down within human sociocultural practices (Santoso et al., 2027; Manohar, 2026; Isnaniah et al., 2023) .

Mathematics plays a vital role in daily life, as almost everything around us is related to mathematics, including culture (Astuti et al., 2021; Hariyani et al., 2021) . The connection between mathematics and culture is referred to as ethnomathematics (Izah & Malasari, 2021) . Ethnomathematics is a learning approach that integrates mathematics with cultural elements, thereby enabling students to better understand, express, and apply mathematical concepts while recognizing the positive values embedded in local culture (Marsigit et al., 2026; Sopamena et al., 2026) .

Ethnomathematics studies often begin with observations of objects and artifacts as cultural works or activities within a specific culture. The subjects of study in ethnomathematics may include aspects of geometry in the architectural design of the Larik traditional house (Wikaningtyas et al., 2022) , geometric elements in the form of kuda lumping props, the arrangement of dancers' formations, accompaniment, and movements (Jannah & Arfinanti, 2025) , geometric aspects in the form of kudus motifs (Maulida et al., 2023) , traditional activities (Astuti et al., 2023) , traditional food (Werdiningsih, 2022) , musical instruments (Supriyono et al., 2021) , temples (Puspitasari & Putra, 2022) , royal palaces , mosques (Zhaara et al., 2024) , and various other objects. These structures contain shapes or elements related to mathematics (V. Salsabila et al., 2023) , which can be studied in the field of geometry (Deda, 2024) .

One of the geometric concepts studied in high school is the geometry of curved-sided three-dimensional shapes, which are commonly found in everyday life. The mathematical concepts studied in this material form the basis for solving mathematical problems (Sumarsono et al., 2022). However, many students struggle to understand the concept of curved-sided three-dimensional shapes (Marasabessy et al., 2021) . This difficulty often arises because teachers do not use teaching aids or learning media in their instruction. Therefore, it is important to design effective learning experiences (Dahlan & Kurniasari, 2022)

As educators in the Society 5.0 era, teachers must possess 21st-century skills, which include the ability to use technology, understand concepts, and deliver instruction effectively (Herizal et al., 2022) . Student boredom acts as a barrier to mathematics learning, leading to disengagement and a loss of interest (Insani et al., 2023) . Interest in learning has a significant impact on mathematics achievement. A high level of interest enables students to actively engage in the learning process and achieve their best performance, particularly in mathematics (Prastika, 2020) . Mathematics learning becomes more engaging through the use of interactive technology, which can enhance student motivation and interest. 21st-century learning activities require active student engagement, the development of higher-order thinking skills, and the use of technology in learning (Rafiqoh, 2020) .

Effective learning can be achieved through the use of technology with digital teaching materials. Traditionally, student worksheets (LKPD) have been used as printed teaching materials in schools (Kholifahtus et al., 2021). LKPDs consist of a series of steps or task instructions, covering both theoretical and practical activities, to achieve learning objectives (Luthfi & Rakhmawati, 2022). LKPDs significantly influence the learning process by advancing students' thinking skills, thereby facilitating their problem-solving abilities (Rewatus et al., 2020). Technological advancements drive the evolution of learning, including the use of technology-based instructional materials (Ridho et al., 2024). Thus, the development

of instructional materials aligned with technological advancements is necessary to enhance students' enthusiasm and interest in learning (Aulia & Herlina Usman, 2023) . One form of technology-based instructional material is the Electronic Student Worksheet (E-LKPD).

E-LKPD is a digital worksheet containing materials and exercises that guide students in understanding the subject matter; it is designed with various features to support self-directed learning (Sumanik & Siregar, 2023) . E-LKPD is considered a better learning resource than printed worksheets. The use of E-LKPD offers several advantages, such as cost-effectiveness, time and space efficiency, long-term availability in digital form, and environmental friendliness (Agustin et al., 2023). E-LKPD is also more practical and can be designed according to teachers' preferences and creativity. Ethnomathematics-based E-LKPDs are digital worksheets that serve as learning guides, containing materials and tasks related to culture. However, from an ethnomathematics perspective, E-LKPDs should not merely digitize exercises or incorporate culture as a learning context. E-LKPD must facilitate students in constructing mathematical meaning from cultural artifacts by reconstructing the mathematical ideas embedded in the forms, structures, patterns, and spatial relationships found within the culture (Santoso et al., 2027; Manohar, 2026; Rosa & Orey, 2011).

Based on observations and interviews with teachers at Al Rifa'ie Junior High School (SMP) in Gondanglegi, Malang, it was found that print media such as textbooks are commonly used in instruction, and only a few teachers utilize student worksheets (LKPD). Although electronic media such as laptops and LCD projectors have been used, their utilization has not been maximized. The mathematics teaching approach at the school remains contextual and has never implemented culture-based learning. Contextual learning at the school is based on real-life situations surrounding the students. However, the integration of cultural values into mathematics instruction has not been implemented. Teachers explained that students are more interested in learning using technology-assisted media. Interviews with students also revealed that they face difficulties in calculating the area and volume of curved-sided three-dimensional shapes. Students stated they are more enthusiastic about learning with electronic media that is engaging, not monotonous, and features attractive, colorful designs.

Several studies on student worksheets in mathematics learning related to culture have been conducted, such as the study which developed ethnomathematics-based worksheets on flat-sided three-dimensional shapes for ninth-grade students. This study produced engaging worksheets that made students more active and interested in learning about three-dimensional shapes. However, that study was conducted in print format and did not test the effectiveness of the product. Another study by (Liesandra & Nurafni, 2022) developed ethnomathematics-based E-LKPDs for plane geometry material in elementary school. This E-LKPD allows students to think freely and learn directly from their cultural environment, thereby facilitating the application of mathematical concepts. Unlike previous studies, this research focuses on curved-sided three-dimensional shapes at the secondary school level using an electronic format. The cultural context used is the Tiban Mosque, and the development model employed is the ADDIE model (Analysis, Design, Development, Implementation, and Evaluation) through to the final stage. Research on ethnomathematics for curved-surface three-dimensional shapes at the secondary school level, particularly using the cultural context of the Tiban Mosque in E-LKPD, is still rare, thus creating a research gap. The uniqueness of this study lies in the reconstruction of solid geometry concepts of curved surfaces from the architectural features of the Tiban Mosque into ethnomathematics-based E-LKPD.

The urgency of this research lies in the integration of three key aspects: the need for contextual mathematics learning, ethnomathematics as a means of cultural preservation, and the utilization of digital technology. This study employs the Tiban Mosque in the development of E-LKPD to enhance students' understanding of curved-surface three-dimensional shapes through interactive technology. By using live worksheets, this E-LKPD incorporates mathematical elements related to curved-sided three-dimensional shapes found in the Tiban Mosque, thereby helping students understand these concepts. This E-LKPD also includes information about the history of the Tiban Mosque, thus providing students with knowledge not only in mathematics but also cultural insights.

## 2. Method

This study is a Research and Development (R&D) study aimed at developing an E-LKPD (Electronic Student Worksheet) on curved-sided three-dimensional shapes integrated with ethnomathematics based on the Tiban Mosque for ninth-grade students. The development model used in this study is the ADDIE model (Analysis, Design, Development, Implementation, and Evaluation). The ADDIE model was chosen because

it has systematic and simple stages, allowing for clarity and ease of understanding (Nurhikmah et al., 2023). Additionally, the ADDIE model offers flexibility for conducting evaluations at each stage (Nadania et al., 2024).

**Research Design and Procedures**

a) Analysis: In *the analysis* stage, the researchers not only analyzed the curriculum, student characteristics, and the use of media in mathematics learning but also conducted a cultural analysis of the Tiban Mosque as a source of ethnomathematics. This cultural analysis was conducted through direct observation, visual documentation, and the identification of architectural elements of the Tiban Mosque that potentially contain mathematical concepts. This process is based on the view that ethnomathematics studies mathematical knowledge arising from cultural practices, while cultural artifacts can be interpreted as representations of mathematical ideas embedded within society (Santoso et al., 2027; Manohar, 2026; Rosa & Orey, 2011). The criteria used to identify geometric elements include:

(1) the presence of shape similarities with curved-sided three-dimensional figures, such as cylinders, cones, and spheres;

(2) the relevance of these elements to 9th-grade geometry material;

(3) sufficient visual clarity so that they are easily recognizable by students; and

(4) the elements are transformed into meaningful learning activities.

b) Design: In the *design* phase, the identified cultural elements are mapped to relevant mathematical concepts and subsequently transformed into task designs within the E-LKPD. This transformation is carried out through a clear process: cultural objects are first identified, then the mathematical concepts they contain are determined, and finally, these concepts are developed into activities, questions, illustrations, and exercises in the E-LKPD. Thus, the design process does not merely start from formal geometry topics but from the reconstruction of the architectural elements of the Tiban Mosque into mathematical representations that students can learn. The concept mapping of ethnomathematics at the Tiban Mosque is shown in Table 1.

**Table 1.** Mapping of Ethnomathematics Concepts of the Tiban Mosque

| Cultural Elements of the Tiban Mosque | Mathematical Concepts | Task Design in the E-LKPD |
|---|---|---|
| Mosque dome | Half-sphere / sphere | Students identify the shape of the dome, determine its elements, and then solve problems involving surface area or volume modified from the dome's shape |
| Mosque minaret | Cylinder | Students observe the shape of the minaret, determine the radius and height, and then calculate the lateral surface area, total surface area, or volume |
| Tower roof or pinnacle ornament | Cone | Students associate roof shapes with cones, identify the slant height, height, and radius, and then solve contextual problems |
| Specific curved ornaments | Combinations of cylinders and cones / curved geometric shapes | Students analyze composite shapes, break them down into their components, and then calculate simple geometric measurements based on illustrations |
| Architectural structures resulting from the visualization of the Tiban Mosque | Relationships between curved-sided spatial figures | Students compare several building elements and determine the type of spatial figure and its mathematical rationale |

Based on Table 1, The Tiban Mosque serves as a cultural context for integrating ethnomathematical concepts into the E-LKPD (Electronic Student Worksheet). Various architectural elements, including the mosque dome, minaret, tower roof, and decorative ornaments, are explored to identify their relationships with three-dimensional geometric shapes, such as spheres, cylinders, cones, and composite solids. These cultural elements are transformed into contextual mathematics tasks that encourage students to observe, identify geometric properties, determine relevant measurements, compare spatial structures, and solve problems involving surface area and volume. Through this approach, the E-LKPD connects local cultural heritage with mathematical learning, making abstract geometric concepts more meaningful, contextual, and engaging.

1) Development: The digital worksheets were created and validated by subject matter experts and media specialists. The feedback provided was used to make revisions to ensure the product met learning needs.
2) Implementation: The product was pilot-tested in three 9th-grade classes at SMP Al-Rifa'ie Gondanglegi, with one class for a limited pilot and two classes for a broader pilot. Student and teacher feedback, as well as learning outcomes, were collected during this phase.
3) Evaluation: Data from expert validation, response questionnaires, and student learning outcomes were analyzed to assess the validity, practicality, and effectiveness of the E-LKPD.

**Population and Participants**

This study involved ninth-grade students at Al-Rifa'ie Junior High School in Gondanglegi, with the criteria that students had studied curved-sided three-dimensional shapes and were able to use digital devices such as *smartphones* or laptops.

**Data Collection Instruments**

The data collection instruments in this study consist of quantitative and qualitative instruments. Quantitative instruments include the content expert validation sheet, the media expert validation sheet, teacher and student response questionnaires, and a learning outcome test. The content expert validation sheet consists of 16 statements covering three aspects: content, language, and benefits. The media expert validation sheet consists of 15 statements covering four aspects: content, language, practicality, and benefits. Meanwhile, the teacher and student response questionnaires were designed based on five aspects: content, language, presentation, practicality, and benefits. Qualitative data were obtained through classroom observations and interviews with teachers and students.

**Data Analysis Techniques**

Data analysis was conducted to assess the validity, practicality, and effectiveness of the developed E-LKPD. Expert validation data were analyzed to determine the product's validity level, while teacher and student response questionnaire data were analyzed to determine the product's practicality level. The product's effectiveness was analyzed using students' learning test results. After conducting the prerequisite tests and determining that the data were not normally distributed, the effectiveness analysis proceeded using nonparametric statistics. In this study, a one-sample binomial test was employed to evaluate the effectiveness of the E-LKPD based on the proportion of students achieving learning mastery. Students' learning outcomes were categorized into two groups according to the established passing score: scores $\leq 70$ (not achieving mastery) and scores $> 70$ (achieving mastery). The binomial test was selected because the primary objective was to determine whether the proportion of students achieving learning mastery exceeded a predefined reference proportion, rather than to examine the normality of the score distribution.

The reference proportion was set at 0.75 (75%), representing the minimum expected proportion of students who should achieve learning mastery for the E-LKPD to be considered effective. This threshold should be consistent with the effectiveness criteria established in the study design or supported by relevant educational standards. Accordingly, the hypotheses were formulated as follows:

$H_0 : p = 0.75$, indicating that the proportion of students achieving a score above 70 is equal to 75%.

$H_1 : p > 0.75$, indicating that the proportion of students achieving a score above 70 exceeds 75%.

Here, p denotes the population proportion of students achieving a score above 70 after using the E-LKPD. The one-sided binomial test was conducted to determine whether the observed proportion of students achieving learning mastery was statistically significantly greater than the predefined 75% threshold. Evidence supporting this hypothesis would indicate that the proportion of students achieving learning mastery exceeded the minimum expected level.

## 3. Results and Discussion

### 3.1 Results

The product developed in this study is an Electronic Student Worksheet (E-LKPD) for the topic of curved-sided three-dimensional shapes, incorporating the cultural context of the Tiban Mosque. This E-LKPD was delivered via the LiveWorksheet digital platform. The development process followed the ADDIE model, which consists of five stages: Analysis, Design, Development, Implementation, and Evaluation.

## A. Analysis

In the analysis stage, we began by identifying cultural elements that could serve as sources for mathematics learning. This analysis not only examined the physical form of the Tiban Mosque but also sought to explore the cultural meanings embedded within its architectural structure. This process linked cultural objects to relevant mathematical concepts, such as curved-sided three-dimensional shapes found in the forms of domes and minarets

1) Curriculum Analysis

The curriculum analysis focuses on the selection of relevant mathematical content, learning outcomes, and the objectives expected to be achieved by the students. The content selected for this study is curved-sided three-dimensional shapes for ninth-grade students at SMP Al-Rifa'ie Gondanglegi. The curriculum used at the school is the Merdeka Curriculum.

2) Analysis of Student Characteristics

Interviews with teachers and students, as well as classroom observations, were conducted to understand student characteristics. Based on the interview results, it was found that students often struggled to maintain focus during lessons. They had difficulty calculating the surface area and volume of curved-sided three-dimensional shapes. However, students showed greater enthusiasm when technology-assisted media were used in instruction. Visually appealing, colorful, and non-monotonous media helped increase students' interest in learning. Additionally, students stated that they had never experienced mathematics instruction that integrated cultural elements.

3) Analysis of Media Utilization

Interviews with teachers and students revealed that the use of media in mathematics instruction is not yet optimal. Although the school has a multimedia room and an LCD projector, most teachers still rely heavily on print media such as textbooks and printed worksheets from publishers. Only a few teachers use self-made student worksheets (LKPD). Current mathematics instruction focuses on contextual learning, where real-life situations around students are used as examples. However, cultural values have not been integrated into instruction, and no cultural elements have been incorporated into the mathematics curriculum.

## B. Design

In the design phase, the E-LKPD is designed not only to convey mathematical concepts but also to introduce students to local cultural values. This process facilitates students in building their mathematical understanding in a more contextual way, through a direct connection between mathematical concepts and their cultural lives. Every cultural element found at the Tiban Mosque is transformed into a learning task that allows students to actively explore and connect mathematical concepts with their own culture.

The devices used in the development of the E-LKPD include laptops and smartphones. Smartphones are used to take the necessary pictures or photos for the worksheets, while laptops are used to write the content. Microsoft Word was used to design the E-LKPD. Microsoft Word was used to compile the E-LKPD, write formulas and symbols, and illustrate curved-sided three-dimensional shapes. The components included in the E-LKPD are:

1) Cover Page

The cover page, as shown in Figure 1.




**Figure 1.** Cover Page

Cover page in Figure 1, contains the title, images of curved-sided three-dimensional shapes (cylinder, cone, sphere), a photo of the Tiban Mosque, columns for entering the student's name and class, the school and campus logos, and the researcher's name.

2) Learning Outcomes, Learning Objectives, and Instructions

Figure 2 consists of Figure 2a, Figure 2b, and Figure 2c. Figure 2a shows the learning outcomes, Figure 2b shows the instructions, and Figure 2c shows the learning objectives.

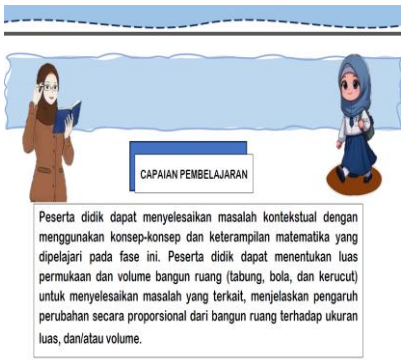



**Figure 2a**. Learning outcomes

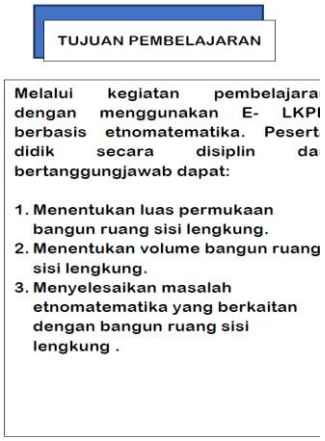



**Figure 2c.** Learning objectives

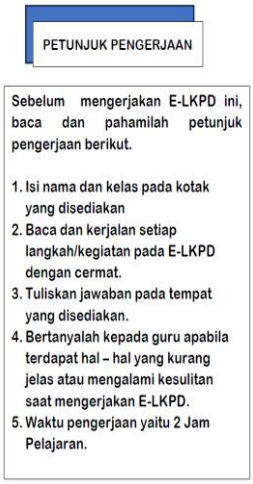



**Figure 2b**. Instructions for carrying out the work

**Figure 2.** Learning Outcomes, Learning Objectives, and Instruction

Figure 2a. The Learning Outcomes cover measuring the surface area and volume of three-dimensional shapes with curved sides, as well as solving related contextual problems. Figure 2b. The

Instructions for Completion consist of reading the instructions, studying the material, completing each activity in the E-LKPD, and writing down the answers carefully. Figure 2c. covers the Learning Objectives: To identify and calculate the surface area and volume of three-dimensional shapes with curved sides through ethnomathematics problems. The learning outcomes and learning objectives aligned with the curriculum in effect at the school.

3) Brief History of Tiban Mosque and Video About Its 10 Floors

The brief history of Tiban Mosque, as shown in Figure 3.




**Figure 3.** Brief History of the Tiban Mosque

Figure 3 contains information about its location, origins, and construction process, as well as a video explaining the contents and functions of each floor of Tiban Mosque. This video serves as supplementary knowledge for students regarding the mosque.

4) Interpretation of the Tiban Mosque Structure

Figure 4 shows Interpretation of the Tiban Mosque Structure.

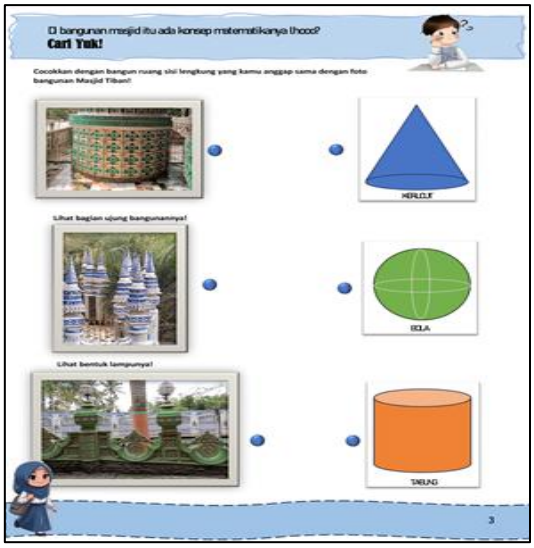



**Figure 4.** Interpretation of the Tiban Mosque

Figure 4 shows three photographs of parts of the Tiban Mosque and three curved-surface shapes (cylinder, cone, sphere). Pupils are asked to match the parts of the Tiban Mosque to the corresponding curved-surface shapes.

5) Curved-Surface Shapes

Figure 5 shows a solid with curved faces.




**Figure 5.** a solid with curved faces

Figure 5 presents the definitions, elements, and formulas for the surface area and volume of curved-surface shapes.

6) Sample Problems

This section contains sample problems on concepts and issues related to ethnomathematics in curved-sided three-dimensional shapes.

7) Practice Problems

Figures 6 and 7 show the practice questions.




**Figure 6.** Practice Questions With Answer Keys




**Figure 7.** Practice Questions Without Answers

The practice questions come in two formats: practice questions with answer keys (Figure 6) and multiple-choice questions (Figure 7). These questions relate to contextual issues and the cultural context of the Tiban Mosque.

## C. Development

During the development phase, the design created in Microsoft Word is saved in PDF (Portable Document Format) and uploaded to the LiveWorksheet digital platform. The development process on LiveWorksheet involves the following steps:

1) Uploading the PDF Document
   Figure 8 shows the steps for uploading a PDF document




**Figure 8.** Uploading a Document

In Figure 8, the researcher uploads the PDF file created in Microsoft Word to the LiveWorksheet platform. Once uploaded, the PDF file becomes an E-LKPD page on LiveWorksheet. The next step is to edit the elements within the document.

2) Editing Elements
   Figure 9 shows the steps for editing elements.




**Figure 9.** Editing Elements on LiveWorksheet

In Figure 9, during the editing stage, the researcher fills in the elements where students can enter answers or complete tasks in the E-LKPD.

3) Custom Links and Worksheet Settings

Figure 10 shows the stages of link configuration and adjustment.




**Figure 10.** E-LKPD Settings in LiveWorksheet

Figure 10 illustrates the configuration and adjustment of links. Settings include determining the E-LKPD display after students complete the task, whether the answer key is accessible to students, and whether grading uses whole numbers or decimals.

After the development process in LiveWorksheet is complete, a validity test is conducted on the developed media. The validity test is performed by two experts: a subject matter expert and a media expert. Both experts are lecturers from PGRI Kanjuruhan University in Malang. The results of Content Expert Evaluation are shown in Table 2.

**Table 2.** Content Expert Evaluation

| Validator | Aspect | Score | Category |
|---|---|---|---|
| I | Content Aspect | 33 | Highly Valid |
| | Language Aspect | 10 | |
| | Utility Aspect | 15 | |
| | Total Score | 58 | |
| | Maximum Score | 64 | |
| | Percentage of Total Score | 90.6% | |
| II | Content Aspect | 33 | Highly Valid |
| | Language Aspect | 11 | |
| | Utility Aspect | 16 | |
| | Total Score | 60 | |
| | Maximum Score | 64 | |
| | Percentage of Total Score | 93.7% | |

Based on Table 2, the validation scores from subject matter experts I and II were 58 and 60, respectively, out of a maximum score of 64. The average validation percentage from both subject matter experts was 92.1%, falling into the “Highly Valid” category. Meanwhile, the results of the media expert assesment are shown in Table 3.

**Table 3.** Media Expert Assessment

| Validator | Aspect | Score | Category |
|---|---|---|---|
| I | Display Aspect | 15 | Very Valid |
| | Language Aspect | 10 | |
| | Practicality | 12 | |
| | Utility Aspect | 15 | |
| | Total Score | 52 | |
| | Maximum Score | 60 | |
| | Percentage of Total Score | 86.6% | |
| II | Visual Aspects | 17 | Highly Valid |
| | Language Aspect | 10 | |
| | Practicality Aspect | 12 | |
| | Utility Aspect | 15 | |
| | Total Score | 54 | |
| | Maximum Score | 60 | |
| | Percentage of Total Score | 90% | |

Based on Table 3, the validation scores from media experts I and II were 52 and 54, respectively, out of a maximum score of 60. The average validation percentage from both media experts was 88.3%, falling into the "Very Valid" category.

## D. Implementation

In the implementation stage, the media that had been developed and validated were pilot-tested with students to assess the learning outcomes achieved through the use of the developed E-LKPD. The pilot testing in this study was conducted in two stages: 1) limited field testing (small group) and 2) broader field testing (large group).

### Practicality of the E-LKPD

The student response questionnaire consisted of 5 evaluation aspects with 19 statements. The results of student responses from the limited field trial (small group) are presented in Table 4, with a total of 23 respondents.

**Table 4.** Student Response Results from the Limited Field Trial

| Aspect | Score | Category |
|---|---|---|
| Appearance Aspect | 482 | Very Practical |
| Content Aspects | 240 | |
| Language Aspects | 230 | |
| Practicality | 239 | |
| Utility Aspects | 314 | |
| Total Score | 1468 | |
| Maximum Score | 1748 | |
| Average (%) | 84.00% | |

In Table 4, The results of the limited field trial indicate that the E-LKPD achieved an average practicality score of 84.00%, with a total score of 1,468 out of 1,748. The assessment covered five aspects: appearance, content, language, practicality, and utility. These findings indicate that the developed E-LKPD is categorized as very practical and is suitable for use in mathematics learning.

Meanwhile, the results of the broader field trial (large group) involving 48 students are presented in Table 5.

**Table 5.** Student Response Results from the Larger-Scale Field Trial

| Aspect | Score | Category |
|---|---|---|
| Appearance Aspect | 839 | Very Practical |
| Content Aspect | 643 | |
| Language Aspect | 477 | |
| Practicality | 499 | |
| Utility Aspects | 584 | |
| Total Score | 3132 | |
| Maximum Score | 3648 | |
| Average (%) | 85.8% | |

Based on Table 5, The larger-scale field trial results show that the E-LKPD obtained an average practicality score of 85.8%, with a total score of 3,132 out of 3,648. The assessment covered five aspects: appearance, content, language, practicality, and utility. These results indicate that the E-LKPD falls into the very practical category, confirming its suitability for supporting mathematics learning.

The results of both the limited field trial (Table 4) and the broader field trial (Table 5) indicate that the E-LKPD is highly practical. In the limited trial, the overall score reached 1468 out of 1748 (84.00%), while in the broader trial, the score reached 3132 out of 3648 (85.8%). Both trials categorized E-LKPD as "Very Practical" across all aspects, with the Utility Aspect and the Presentation Aspect receiving the highest scores. These findings indicate that E-LKPD is effective and well-received by students.

The teacher response questionnaire assessed the practicality of the developed E-LKPD. This questionnaire covered 5 aspects: appearance (5 statements), content (5 statements), language (3 statements), practicality (3 statements), and usefulness (4 statements). The results are presented in Table 6.

**Table 6.** Teacher Response Results

| Evaluation Aspect | Teacher 1 | | Teacher 2 | | Average (%) |
|---|---|---|---|---|---|
| | Score | Percentage | Score | Percentage | |
| Appearance Aspect | 19 | 95% | 19 | 95% | 95% |
| Content Aspects | 19 | 95% | 20 | 100% | 97.5% |
| Language Aspects | 12 | 100% | 11 | 91.6% | 95.8% |
| Practicality | 11 | 91.6% | 11 | 91.6% | 95% |
| Benefit Aspect | 15 | 93.7% | 14 | 87.5% | 90.6% |
| Total Score | 76 | | 75 | | |
| Maximum Score | 80 | | 80 | | |
| Total Score Percentage | 95% | | 93.7% | | 94.3% |
| Category | Very Practical | | Very Practical | | Very Practical |

Based on Table 6, the E-LKPD's practicality score reached 94.3% in the "very practical" category, indicating that the ethnomathematics-based E-LKPD is practical and suitable for use in teaching curved-sided three-dimensional shapes. This is supported by the practicality assessment, which was rated as "very practical" by two mathematics teachers. The highest percentage in the content aspect indicates that the E-LKPD helps students better understand curved-sided three-dimensional shapes.

**Effectiveness of the E-LKPD**

Students' learning outcomes (test scores) on the E-LKPD, including the activity of interpreting the Tiban Mosque into the form of a curved-sided three-dimensional shape during a broader field trial, were used to measure the effectiveness of the developed E-LKPD. The results of the limited field trial are not presented here because that trial was conducted solely to assess student responses. The learning outcomes from the broader field trial are shown in Table 7. with a mastery rate of 81.2%, which is categorized as effective.

**Table 7.** Student Learning Outcomes from the Larger-Scale Field Trial

| Total Number of Students | Number | | Achievement Percentage | Category |
|---|---|---|---|---|
| | Score < 70 | Score ≥ 70 | | |
| 48 | 9 | 39 | 81.2% | Effective |

Based on Table 7, the results of the large-scale field trial involving 48 pupils showed that 39 pupils (81.2 per cent) achieved a score of ≥ 70, whilst the remaining 9 pupils (18.8 per cent) scored below 70. The 81.2 per cent pass rate indicates that the majority of pupils have met the specified learning outcome criteria. Consequently, based on the criteria used, the teaching and learning process falls into the 'effective' category. These results indicate that the teaching and learning materials developed are capable of effectively supporting the achievement of students' learning outcomes.

To further validate the effectiveness, a Shapiro-Wilk normality test was conducted. Since the data were not normally distributed (p = 0.007), a binomial test was used. The results, shown in Table 8.

**Table 8**. Binomal Test

**Binomial Test**

| Category | N | Observed Prop. | Test Prop. | Exact Sig. (2-tailed) | Asymp. Sig. (2-tailed) |
|---|---|---|---|---|---|
| Score < 70 | 9 | .19 | .50 | .000 | .000 |
| Score ≥ 70 | 39 | .81 | .50 | .000 | .000 |

a. Based on the binomial distribution.

Table 8 indicate a significance value of 0.000, which is less than 0.05; therefore, H0 is rejected and H1 is accepted. This confirms that E-LKPD significantly improves students' learning outcomes, demonstrating its effectiveness in helping students understand curved-sided three-dimensional shapes.

Based on Table 8, it is known that out of 48 students, 39 students or 81% scored > 70, while 9 students or 19% scored ≤ 70. The results of the binomial test showed a significance value of 0.000, which is smaller than 0.05, so H0 is rejected and H1 is accepted. This indicates that the proportion of students who scored above 70 after learning using the E-LKPD was significantly greater than 50%. Thus, the ethnomathematics-based E-LKPD can be deemed effective because the majority of students achieved mastery of the curved-sided three-dimensional shapes material.

Students demonstrated improved mathematical understanding, as evidenced by their ability to explain the connection between cultural objects and mathematical concepts. They also showed greater enthusiasm for the curved-sided three-dimensional shapes material after relating it to cultural elements they were familiar with. This indicates that the integration of local culture into mathematics learning through the ethnomathematics approach not only helps students understand abstract concepts but also provides them with a more meaningful and relevant context in their daily lives.

### E. Evaluation

During the evaluation phase, data from expert validation, student and teacher response questionnaires, and student learning outcomes were analyzed to assess the overall quality of the developed E-LKPD. The evaluation focused on three main aspects: validity, practicality, and effectiveness. The validity of the E-LKPD is assessed based on expert input that categorizes it as "Highly Valid," confirming that the content, design, and cultural integration are appropriate for use in learning. In terms of practicality, results from both the limited field trial (84%) and the broader field trial (85.8%) indicated that the E-LKPD falls into the "Highly Practical" category, suggesting that students and teachers found the material easy to use and aligned with learning needs. In terms of effectiveness, the broader field trial showed a mastery rate of 81.2% in the effective category, indicating that the E-LKPD significantly helps students understand curved-sided three-dimensional shapes. Based on these findings, it can be concluded that the developed E-LKPD is valid, practical, and effective in improving students' understanding of the mathematical concepts of curved-sided three-dimensional shapes.

## 3.2 Discussion

The validity of the E-LKPD, which reached 90.2% and falls into the "highly valid" category, indicates that the strength of this product lies not only in its technical feasibility but also in its success in reconstructing cultural artifacts into mathematical representations that students can understand. From an

ethnomathematics perspective, mathematics is not viewed as knowledge separate from human life, but rather as knowledge born from social and cultural practices (Leton et al., 2025; Payadnya et al., 2024; Zito & Albanese, 2025) . Therefore, the inclusion of the Tiban Mosque in the E-LKPD serves not merely as a decorative context, but as a source of meaning that enables students to connect formal geometric concepts with real and familiar cultural objects. This finding reinforces the results of the " , but at the same time demonstrates more deeply that the validity of the product is also determined by its success in positioning culture as the foundation for the formation of mathematical meaning, not merely as a supplement to the material.

The high practicality of the E-LKPD, both in expert evaluations and in field trials, also needs to be interpreted more deeply than merely ease of access and use. The average expert practicality score of 100%, along with limited and extensive pilot test results of 84% and 85.8%, respectively, indicate that students can engage with curved-sided three-dimensional shapes through pathways closer to their own experiences. In sociocultural learning theory, knowledge is constructed through a mediation process using tools, symbols, language, and cultural context. The Tiban Mosque can function as a mediating tool between informal and formal mathematical knowledge by providing a culturally meaningful context for mathematical abstraction. Through the exploration of architectural features, students have opportunities to progress from visual recognition to the identification of mathematical properties, the construction of formal representations, and the generalization of mathematical relationships. This process illustrates how familiar cultural objects can serve as starting points for developing more formal mathematical understanding. However, the mosque's role as a mediator should not be inferred solely from its cultural relevance. Rather, this interpretation needs to be supported by empirical evidence showing how students articulate mathematical properties, translate contextual observations into mathematical representations, and apply the resulting concepts beyond the original setting. Triangulating classroom observation records, student work, and interview responses can strengthen the interpretation of the abstraction process and clarify how cultural experiences contribute to mathematical meaning-making.

From a pedagogical perspective, the ethnomathematical process in this E-LKPD becomes evident when students do not merely view the architectural form of the Tiban Mosque as a building but begin to interpret it as a geometric object. The dome, minarets, and other curved elements serve as a starting point for students to identify the shapes of cylinders, cones, or spheres, and then connect them to geometric properties, surface area, and volume. At this stage, culture supports the abstraction process because students are not immediately confronted with symbolic formulas, but rather first with concrete forms that can be observed and interpreted. This is what makes ethnomathematics work effectively: students build mathematical understanding from something they initially know informally within their culture, then gradually transform it into formal knowledge in the classroom (Kwakye et al., 2026; Ntumi et al., 2026) . In this context, the effectiveness of the E-LKPD with an 81.2% mastery rate and significant binomial test results not only demonstrates the success of the product in terms of learning outcomes but also highlights the success of the process of constructing mathematical meaning through culture. These findings align with (Rofiq & Rohman, 2024) as well as (Setiana & Nuryadi, 2022) ; however, this study adds the explanation that such effectiveness occurs because culture functions as a cognitive bridge between concrete experiences and mathematical abstraction.

The role of the Tiban Mosque in learning is also significant as a bridge between informal and formal knowledge. Before learning, students may have had visual or cultural experiences with the architectural forms of mosques, but these experiences do not automatically translate into mathematical knowledge. Through the E-LKPD, these cultural experiences are reorganized into mathematical thinking objects. Students begin to understand that the shapes they see in daily life can be interpreted in the language of school geometry. Thus, the function of the Tiban Mosque in this study is not merely to make learning more engaging, but to help students bridge the gap between what they recognize in their culture and what they must understand in formal mathematics. This finding reinforces the argument of " that culture bridges the gap between formal mathematics and the real world; however, in this study, that bridge appears more clearly through the processes of interpretation, shape identification, and abstraction carried out by students during learning.

Experts' suggestions to clarify the visual representation of the Tiban Mosque, improve the font type, strengthen the introductory video, and add a reflection space also hold significance beyond mere technical improvements. These revisions indicate that cultural objects do not automatically become learning resources simply because they have been incorporated into the media. Cultural artifacts still require pedagogical

mediation so that students can accurately interpret the relationship between cultural objects and mathematical concepts. In this context, visual reinforcement and the introductory video help clarify cultural representations, as supported by (Kustandi et al., 2021; Liesandra & Nurafni, 2022) , while the addition of reflection strengthens the process of concept internalization, as emphasized by (Wowor et al., 2022) . In other words, the success of ethnomathematics-based learning in this study stems not only from the presence of the cultural context itself but also from how that context is mediated, explained, and reflected upon during the learning process.

Nevertheless, the limitations of this study extend beyond technical factors, such as internet connectivity and reliance on digital devices (Hasanah et al., 2019), to include cultural and methodological considerations. In terms of cultural transferability, the relevance of the Tiban Mosque as a learning context may vary depending on students' geographical, social, and cultural proximity to the site. Furthermore, the effectiveness of the ethnomathematics-based E-LKPD may depend on the alignment between the cultural context, students' backgrounds, and the school environment. Therefore, future development of ethnomathematics-based E-LKPDs should preserve the principle of reconstructing mathematical concepts from cultural artifacts while adapting the selected artifacts to students' cultural environments. Methodologically, this study employed a single-group design without a control group or pretest–posttest comparison, using a one-sample binomial test against a reference proportion of 75%. Consequently, the findings indicate whether the proportion of students achieving scores above the passing threshold exceeds the predefined 75% criterion, but they do not establish a causal relationship between the use of the E-LKPD and students' learning outcomes. Future studies should incorporate control groups and pretest–posttest designs to provide stronger evidence of effectiveness.

Overall, this indicates that the effectiveness of ethnomathematics-based E-LKPD in this study does not primarily lie in its digital form, but in its ability to present culture as a medium for mathematical thinking. Through the Tiban Mosque, students do not merely learn about curved-sided three-dimensional shapes as a collection of formulas, but construct knowledge by interpreting cultural objects, identifying shapes, abstracting geometric properties, and connecting informal experiences with formal mathematical concepts. It is at this point that ethnomathematics theory and sociocultural learning theory converge: both position culture not as a backdrop to learning, but as a space where knowledge is formed, negotiated, and internalized by students.

## 4. Conclusion

The development of ethnomathematics-based digital worksheets (E-LKPD) within the cultural context of the Tiban Mosque offers a broader contribution than merely producing usable learning materials. Theoretically, this study affirms that cultural artifacts can be positioned not merely as illustrative contexts but as sources for the formation of mathematical meaning in geometry learning. In relation to ethnomathematics, this study demonstrates that the architectural elements of the Tiban Mosque can be reconstructed into the concept of curved-sided three-dimensional shapes, thereby allowing culture to serve as a bridge between students' informal experiences and the formal structure of school mathematics. This finding reinforces the view that mathematics learning becomes more meaningful when abstract concepts are constructed through cultural objects that are close to students' experiences. Practically, this study has implications for the design of culture-responsive curricula and instruction, particularly in encouraging teachers to develop instructional materials that are not only oriented toward conceptual mastery but also toward recognizing local knowledge as part of the learning process. Thus, ethnomathematics-based E-LKPDs can serve as a model for developing instructional materials that support more contextual, inclusive, and culturally relevant mathematics learning. Future research should expand the study to other cultural contexts to gain a more comprehensive understanding of the transferability of this approach across various learning environments, as well as conduct a more in-depth conceptual analysis of how students construct, negotiate, and transform mathematical meanings from cultural artifacts into formal mathematical concepts.

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