International Journal of Research and Review
[Indexed, Peer-Reviewed Journal]
Volume 13; Issue: 9; September 2026
Website: www.ijrrjournal.com
Research Paper E-ISSN: 2349-9788; P-ISSN: 2454-2237

Development of "Smart Box" Ethnomathematics Media to Improve Students' Learning Outcomes Regarding 3D Shapes

Ika Santia[1], Samijo[2], Wahid Ibnu Zaman[3]

[1,2]Department of Mathematics Education, Faculty of Health and Science, Universitas Nusantara PGRI Kediri, Indonesia.
[3]Postgraduate Program in Primary Education, Universitas Nusantara PGRI Kediri, Indonesia.

Corresponding Author: Ika Santia

DOI: https://doi.org/10.52403/ijrr.20260921

ABSTRACT

This study aimed to develop an Ethnomathematics Smart Box as an interactive learning medium to improve elementary students' learning outcomes in three-dimensional geometry. The study employed a Research and Development approach using the ADDIE model, comprising Analysis, Design, Development, Implementation, and Evaluation stages. The Smart Box integrated ethnomathematics based on Tegowangi Temple, Contextual Teaching and Learning, and hands-on activities. Participants included fifth-grade students at SDN Sukorame 2, Kediri. Data were collected through observation, interviews, expert validation, questionnaires, and pretest-posttest assessments. The results showed that the Smart Box achieved an overall validity score of 92.13%, categorized as very valid. Practicality assessments yielded an overall score of 92.32%, indicating that the medium was very practical. Students' mean learning outcomes increased from 61.56 on the pretest to 84.31 on the posttest, with an N-gain score of 0.59 in the moderate category. A paired-samples t-test revealed a statistically significant difference, $t(31) = -12.84$, $p < .001$. The findings indicate that the Ethnomathematics Smart Box is a valid, practical, and effective medium for supporting students' understanding of three-dimensional geometry while connecting mathematics with local cultural heritage.

Keywords: Ethnomathematics, Smart Box, Learning Outcomes, Three-Dimensional Geometry, Elementary School.

INTRODUCTION

Culture is a process of habitual practices that embodies important and fundamental values passed down from generation to generation (1–3). These values not only shape people's ways of life but also reflect the worldview, norms, and ethical principles upheld by a particular community. In education, culture plays an important role as a source of inspiration for creating meaningful and contextual learning processes (4,5). When local culture is utilized as a learning resource, students tend to feel more connected and emotionally engaged in the learning process. This can increase learning motivation while strengthening students' character based on the cultural values of the nation. Therefore, the integration of local culture into education needs to be systematically promoted so that education in Indonesia not only produces intellectually capable generations but also develops students with strong character and national awareness. Such cultural integration can also be implemented across various school subjects, including mathematics, which has strong connections with cultural activities and practices in everyday life (6–9).

Mathematics is a subject taught at all levels of formal education. During the learning process, students often encounter difficulties, particularly because teachers do not sufficiently provide visual representations of abstract mathematical concepts (10,11). As a result, students may perceive mathematics in real life as substantially different from the mathematics taught at school (12–14). In reality, however, mathematics is closely connected to everyday activities. Within mathematics education, there is a field known as ethnomathematics, which examines the relationship between mathematical concepts and the cultural practices of particular communities (15). Ethnomathematics explores how cultural elements, including traditions, beliefs, daily activities, and distinctive community symbols, contain mathematical ideas that can be utilized as learning resources (16–18). Ethnomathematics can be understood as a culturally relevant mathematical approach for examining how people think and apply mathematical concepts within particular cultural contexts. In other words, ethnomathematics helps us understand how communities employ mathematical principles in their daily lives, either explicitly or implicitly (19).

Regarding ethnomathematics, observations were conducted in Classes 5A and 5B at SDN Sukorame 2. The findings indicated that although teachers had attempted to use various learning media, many students remained unfocused, passive, and experienced difficulties in understanding geometric concepts. In Class 5A, the mathematics teacher used concrete objects available in the students' surroundings. However, these media were static and presented as "ready-made" objects, making it difficult for students to deeply visualize the properties of three-dimensional shapes because the objects could not be disassembled to reveal their structural components. Meanwhile, in Class 5B, the mathematics teacher utilized digital media in the form of animations, but its use was not sufficiently interactive to maintain students' concentration throughout the lesson. Furthermore, the learning process had not been connected to local cultural heritage, such as Tegowangi Temple. Consequently, 100% of the students were unaware of the mathematical elements embedded in historical buildings within their surrounding environment. Similar problems have also been identified in previous research (20), which reported that the lack of local cultural integration in learning prevents students from connecting mathematical concepts with their surrounding environment. In fact, various cultural buildings and heritage sites contain geometric concepts that can serve as contextual learning resources, making mathematics learning more meaningful and relevant to students' lives. This situation demonstrates the urgency of research on mathematics learning that integrates local culture.

Interviews were subsequently conducted with the mathematics teachers of Classes 5A and 5B to explore these problems further. The interview results indicated that 30% of students were still unable to understand the material adequately, partly due to affective barriers, particularly *math anxiety*, experienced by more than 40% of students. In addition, teachers explained that students had never directly visualized geometric nets through hands-on construction activities. Consequently, they had difficulty understanding the complete process of transforming two-dimensional nets into three-dimensional shapes. The limitations of ready-made physical objects, such as packaging materials found in students' surroundings, create a visualization gap because students cannot observe the transformation from flat surfaces into three-dimensional structures. Therefore, a solution is needed through the development of interactive learning media capable of visualizing the properties of three-dimensional shapes based on their structural components. Based on the background described above, the research questions are formulated as follows: 1) How can a valid, practical, and effective ethnomathematics Smart Box be developed? 2) Does the use of the ethnomathematics Smart Box improve students' learning outcomes in three-dimensional geometry?

The study contributes to the field in two ways. Theoretically, it extends the application of ethnomathematics by positioning cultural heritage not merely as a contextual illustration but as a foundation for interactive spatial learning. Practically, it provides a culturally responsive manipulative learning medium that can help teachers address students' difficulties in visualizing three-dimensional geometry. More broadly, the study demonstrates how local cultural heritage can be transformed into an educational resource that simultaneously supports mathematical understanding and students' appreciation of cultural identity.

MATERIALS & METHODS

Research Design

This study employed a Research and Development (R&D) design to develop and evaluate an Ethnomathematics Smart Box as an interactive learning medium for three-dimensional geometry in elementary schools. The R&D approach was selected because the study was not only intended to investigate the effectiveness of an existing instructional strategy but also to produce a new educational product and systematically evaluate its quality before implementation. The development process integrated ethnomathematics, Contextual Teaching and Learning (CTL), and hands-on learning to connect formal geometric concepts with the local cultural heritage of Tegowangi Temple.

The development procedure adopted the ADDIE model, consisting of five systematic stages: Analysis, Design, Development, Implementation, and Evaluation. In the Analysis stage, the researchers identified students' learning difficulties, teachers' needs, characteristics of existing learning media, students' understanding of the mathematical elements of Tegowangi Temple, and the learning context of three-dimensional geometry. The Design stage focused on developing the conceptual framework, learning objectives, Smart Box components, geometric activities, student worksheets, teacher guidelines, and assessment instruments. Particular attention was given to designing activities that enabled students to manipulate geometric nets and reconstruct them into three-dimensional shapes.

During the Development stage, the prototype was produced and subjected to expert validation, involving experts in mathematics education/materials and instructional media. The validation process assessed the appropriateness of the content, accuracy of geometric concepts, visual design, usability, cultural relevance, instructional quality, and alignment between the Smart Box activities and the intended learning outcomes. Revisions were conducted based on expert recommendations before field implementation.

The Implementation stage involved the use of the revised Smart Box in elementary geometry learning. Students engaged in hands-on activities involving exploration, identification, assembly, and reconstruction of geometric nets using contexts derived from Tegowangi Temple. The effectiveness of the product was evaluated through a one-group pretest-posttest design, in which students' learning outcomes were measured before and after the intervention. Student and teacher responses were also collected to determine the practicality and acceptability of the developed medium.

Finally, the Evaluation stage involved both formative and summative evaluation. Formative evaluation was conducted throughout the development process to identify weaknesses and improve the prototype, while summative evaluation examined the overall validity, practicality, and effectiveness of the final product. Quantitative data were analyzed using descriptive statistics, percentage-based validity and practicality scores, N-gain analysis to determine the magnitude of learning improvement, and a paired-samples t-test to examine whether the difference between pretest and posttest scores was statistically significant. Through this design, the study systematically connects needs analysis → culturally contextualized design → expert validation → classroom implementation → empirical evaluation, ensuring that the Ethnomathematics Smart Box is pedagogically appropriate, practically usable, and empirically supported as a medium for elementary geometry learning.

Participant and Context

The study was conducted at SDN Sukorame 2, Kediri, East Java, Indonesia, an elementary school selected based on the results of preliminary observations indicating students' difficulties in understanding three-dimensional geometry and the limited integration of local cultural contexts into mathematics learning. The school was considered appropriate research setting because it is located within the cultural environment of Kediri, where Tegowangi Temple provides a relevant local context for identifying and exploring geometric concepts.

The participants consisted of fifth-grade elementary school students from Classes 5A and 5B, as well as mathematics teachers involved in the learning process. The fifth-grade students were selected because three-dimensional geometry is included in the elementary mathematics curriculum and requires students to develop spatial visualization skills, particularly in understanding geometric nets, properties of solid figures, and the transformation of two-dimensional representations into three-dimensional forms. The preliminary stage involved students from both classes to identify learning needs and classroom conditions. The implementation and effectiveness testing involved students who participated directly in learning activities using the developed Ethnomathematics Smart Box.

In addition to students and teachers, expert validators were involved in evaluating the quality of the developed product. The validators consisted of experts in mathematics education/materials and learning media. Their role was to assess the content accuracy, instructional appropriateness, visual and physical design, usability, cultural relevance, and alignment of the Smart Box with the intended learning objectives.

The research context was designed around three-dimensional geometry learning through the cultural context of Tegowangi Temple. Students were introduced to geometric elements identified in the temple's architectural structures and subsequently engaged in hands-on activities using the Smart Box. The learning activities required students to identify geometric shapes, examine their components, construct and deconstruct geometric nets, and relate the resulting three-dimensional forms to the cultural context. This setting enabled the researchers to examine not only students' cognitive learning outcomes but also the practicality and contextual relevance of the developed medium. Ethical considerations were observed throughout the study. Participation was conducted in accordance with school procedures, and the research activities were integrated into regular mathematics learning without disrupting the students' educational program. Student data were used solely for research and evaluation purposes, with participant identities kept confidential.

Data Collection Procedures

Data collection was conducted systematically throughout the development and implementation of the Ethnomathematics Smart Box. The procedures were designed to obtain comprehensive evidence regarding students' needs, product validity, practicality, and effectiveness. Data were collected through observation, interviews, expert validation, questionnaires, and learning outcome tests.

First, preliminary observations were conducted in Classes 5A and 5B at SDN Sukorame 2 to identify the existing mathematics learning conditions. The observations focused on students' engagement, learning difficulties, the types and characteristics of instructional media used by teachers, opportunities for hands-on activities, and the extent to which local culture was incorporated into mathematics instruction. Particular attention was given to students' ability to visualize three-dimensional shapes and their understanding of the relationship between geometry and Tegowangi Temple. **Second**, semi-structured interviews were conducted with the mathematics teachers of Classes 5A and 5B. The interviews explored teachers' perceptions of students' difficulties in learning three-dimensional geometry, students' affective barriers such as mathematics anxiety, the use of existing learning media, students' experience with constructing geometric nets, and teachers' needs for more interactive and contextual learning media.

Third, expert validation was conducted after the initial Smart Box prototype had been developed. Material and media experts evaluated the product using structured validation instruments. The assessment covered the accuracy and relevance of geometric content, instructional quality, cultural appropriateness, physical and visual design, usability, safety, and alignment with the learning objectives. Expert comments and suggestions were documented and used to revise the prototype before classroom implementation. **Fourth**, practicality data were collected through teacher and student response questionnaires following the implementation of the revised Smart Box. The questionnaires examined ease of use, attractiveness, clarity of instructions, students' engagement, suitability of the activities, and the perceived usefulness of the medium for learning three-dimensional geometry.

Fifth, learning outcome data were collected using a pretest and posttest. The pretest was administered before students used the Ethnomathematics Smart Box to determine their initial understanding of three-dimensional geometry. After the intervention, the same learning objectives were assessed through a posttest. The test items measured students' understanding of geometric properties, identification of geometric nets, spatial visualization, and the ability to relate two-dimensional nets to three-dimensional forms. **Finally**, all quantitative and qualitative data were systematically documented and coded for analysis. The pretest and posttest scores were used to determine changes in students' learning outcomes, while validation and questionnaire data were used to establish the validity and practicality of the developed product. Expert comments, teacher interviews, and classroom observations were used as supporting qualitative evidence for product refinement and interpretation of the quantitative findings.

Data Analysis

The data analysis was conducted using a mixed-methods approach, combining quantitative and qualitative analyses to determine the validity, practicality, and effectiveness of the Ethnomathematics Smart Box. Quantitative data were obtained from expert validation sheets, teacher and student response questionnaires, and pretest-posttest results, while qualitative data were derived from classroom observations, teacher interviews, and expert suggestions.

1. Validity Analysis

The validity of the Ethnomathematics Smart Box was determined from assessments provided by material and media experts. Each item was rated using a Likert scale. The validity score was calculated using the percentage formula:

$$V = \frac{\sum X_{max}}{\sum x} \times 100\%$$

where V represents the validity percentage, ∑X is the total score obtained, and ∑Xmax is the maximum possible score. The resulting percentage was interpreted using predetermined validity criteria, ranging from invalid to very valid. Qualitative comments from the validators were analyzed descriptively and used to revise the product.

2. Practicality Analysis

Product practicality was analyzed using responses from mathematics teachers and students after the implementation of the Smart Box. The percentage of practicality was calculated as:

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

The analysis focused on ease of use, clarity of instructions, attractiveness, accessibility of the components, student engagement, and suitability of the learning activities. Higher percentages indicated greater practicality and acceptability of the learning medium.

3. Effectiveness Analysis

The effectiveness of the Smart Box was examined by comparing students' learning outcomes before and after implementation. Descriptive statistics, including the mean, minimum, maximum, and standard deviation, were calculated for both pretest and posttest scores.

Learning improvement was further determined using the normalized gain (N-gain):

$$\mathrm{N-gain} = \frac{X_{max} - \overline{X_{postest}}}{\overline{X_{postest}} - \overline{X_{pretest}}} \times 100\%$$

The N-gain value was interpreted as low, medium, or high improvement. This analysis provided information about the magnitude of students' learning improvement rather than merely identifying differences in raw scores.

To determine whether the improvement was statistically significant, a paired-samples t-test was conducted because the pretest and posttest scores were obtained from the same participants. Before conducting the test, assumptions of normality were examined. The statistical hypothesis was formulated as follows:

H_0: There is no significant difference between students' pretest and posttest scores.

H_1: There is a significant difference between students' pretest and posttest scores.

The significance level was set at $\alpha = 0.05$. If the obtained p-value was less than 0.05, H_0 was rejected, indicating a statistically significant improvement in students' learning outcomes following the use of the Ethnomathematics Smart Box. Where appropriate, effect size was also calculated to determine the practical magnitude of the intervention beyond statistical significance.

4. Qualitative Data Analysis

Qualitative data from classroom observations, teacher interviews, and expert feedback were analyzed through data reduction, data organization, interpretation, and conclusion drawing. The analysis focused on recurring themes related to students' engagement, spatial visualization difficulties, interaction with the Smart Box, cultural connections, and usability of the learning activities. These findings were used to complement the quantitative results and explain how and why the Smart Box supported geometry learning.

Overall, the combination of validity analysis, practicality analysis, N-gain, paired-samples t-test, effect size, and qualitative thematic analysis provided comprehensive evidence regarding the quality and effectiveness of the Ethnomathematics Smart Box as a culturally contextualized learning medium for elementary geometry.

RESULT

Analysis of Students' Needs and Learning Context

The analysis stage was conducted through classroom observations and semi-structured interviews with teachers of Classes 5A and 5B at SDN Sukorame 2, Kediri. The findings confirmed several challenges in learning three-dimensional geometry. Although teachers had used concrete objects and digital media, the available learning media were generally static or insufficiently interactive. Consequently, students experienced difficulties in visualizing the transformation of two-dimensional nets into three-dimensional objects.

The preliminary findings also indicated that approximately 30% of students experienced difficulties in understanding three-dimensional geometry. Furthermore, more than 40% of the students showed indications of mathematics anxiety during geometry learning. Another important finding was that students had limited knowledge of the mathematical elements embedded in their local cultural environment. All students involved in the preliminary observation were unfamiliar with the geometric potential of Tegowangi Temple as a contextual resource for mathematics learning.

These findings demonstrated the need for a learning medium that could simultaneously provide concrete manipulation activities, support spatial visualization, and connect mathematical concepts with local cultural heritage. Based on these needs, the Ethnomathematics Smart Box was designed as an interactive medium containing geometric models, nets of three-dimensional shapes, Tegowangi Temple-based visual representations, student worksheets, and instructional guidelines.

Development of the Ethnomathematics Smart Box

The development process followed the ADDIE model, including the stages of Analysis, Design, Development, Implementation, and Evaluation. During the design stage, the Smart Box was conceptualized to facilitate students' exploration of geometric concepts through hands-on activities. Students were encouraged to identify geometric forms, manipulate two-dimensional nets, construct three-dimensional shapes, and relate the resulting objects to architectural elements associated with Tegowangi Temple.

The initial prototype consisted of several interconnected components: (1) a Smart Box container, (2) manipulable models of three-dimensional shapes, (3) detachable geometric nets, (4) ethnomathematics-based visual materials related to Tegowangi Temple, (5) student worksheets, and (6) teacher guidelines. The design emphasized active student participation and contextual learning rather than passive observation of ready-made objects.

PICTURE 1. Prototype of Smartbox of Ethnomathematics

Following expert evaluation, several revisions were made to improve the product. These revisions included clarifying the instructions for constructing geometric nets, improving the visual representation of cultural objects, strengthening the connection between temple elements and geometric concepts, and adjusting the size and arrangement of several manipulatives to make them easier for elementary school students to use.

Validity of the Ethnomathematics Smart Box

The validity of the developed product was assessed by experts in mathematics education and instructional media. The evaluation covered content accuracy, instructional quality, cultural relevance, visual design, usability, and alignment with the intended learning objectives. Table 1 presents the results of the expert validation.

TABLE 1. Expert Validation Results of the Ethnomathematics Smart Box

Aspect	Material Expert (%)	Media Expert (%)	Mean (%)	Category
Content accuracy	94.00	–	94.00	Very valid
Learning objectives and instructional relevance	92.00	90.00	91.00	Very valid
Cultural relevance	94.00	91.00	92.50	Very valid
Visual and physical design	–	93.00	93.00	Very valid
Usability	91.00	92.00	91.50	Very valid
Overall mean	**92.75**	**91.50**	**92.13**	**Very valid**

The overall validation score of 92.13% indicates that the Ethnomathematics Smart Box met the criteria of a very valid learning medium. The material expert particularly emphasized the appropriateness of the geometric content and the integration of cultural contexts. Meanwhile, the media expert highlighted the attractiveness, accessibility, and interactive characteristics of the Smart Box.

The validation results also showed that the developed medium had successfully integrated three important elements: mathematical concepts, hands-on learning activities, and local cultural contexts. Therefore, after minor revisions based on the experts' recommendations, the product was considered suitable for classroom implementation.

Practicality of the Ethnomathematics Smart Box

The practicality of the Smart Box was evaluated through teacher and student response questionnaires following its implementation in geometry learning. The assessment focused on ease of use, clarity of instructions, attractiveness, student engagement, and the perceived usefulness of the medium. The results are presented in Table 2.

TABLE 2. Practicality Results of the Ethnomathematics Smart Box

Respondent	Number of Respondents	Mean Percentage (%)	Category
Mathematics teacher	2	94.00	Very practical
Students	32	90.63	Very practical
Overall mean	34	92.32	Very practical

The results demonstrate that the Ethnomathematics Smart Box was highly practical for classroom use. Teachers reported that the medium was easy to implement and supported the delivery of abstract geometric concepts. The teacher responses also indicated that the availability of structured learning activities and teacher guidelines facilitated the implementation process.

Students responded positively to the use of the Smart Box. Most students considered the learning activities interesting and easier to understand because they were able to directly manipulate the geometric components. The hands-on activities enabled students to observe how two-dimensional nets could be folded and reconstructed into three-dimensional forms.

Classroom observations further supported the questionnaire findings. During the implementation, students showed greater participation in identifying geometric characteristics, constructing models, and discussing the relationship between mathematical concepts and local cultural objects. These observations suggest that the Smart Box created a more active learning environment than the previously used static learning media.

Effectiveness of the Ethnomathematics Smart Box on Students' Learning Outcomes

The effectiveness of the developed medium was evaluated using a one-group pretest-posttest design. Students completed a pretest before participating in learning activities using the Ethnomathematics Smart Box and a posttest after the implementation. The descriptive results are presented in Table 3.

TABLE 3. Descriptive Statistics of Students' Learning Outcomes

Test	N	Minimum	Maximum	Mean	Standard Deviation
Pretest	32	42	78	61.56	9.14
Posttest	32	68	96	84.31	7.52

The mean posttest score was substantially higher than the mean pretest score. Students' average learning outcome increased from 61.56 to 84.31, representing an increase of 22.75 points. The improvement indicates that students demonstrated better understanding of the properties of three-dimensional shapes, geometric nets, and the relationship between two-dimensional and three-dimensional representations after participating in the Smart Box learning activities. To determine the magnitude of learning improvement, normalized gain analysis was conducted.

TABLE 4. N-Gain Analysis

N	Mean Pretest	Mean Posttest	Mean N-Gain	Category
32	61.56	84.31	0.59	Medium

The mean N-gain score of 0.59 indicates a moderate improvement in students' learning outcomes. This result suggests that the Ethnomathematics Smart Box contributed meaningfully to students' conceptual understanding of three-dimensional geometry.

Statistical Significance of Learning Improvement

A paired-samples t-test was conducted to examine whether the difference between students' pretest and posttest scores was statistically significant.

TABLE 5. Paired-Samples t-Test Results

Comparison	Mean Difference	t	df	Sig. (2-tailed)
Pretest–Posttest	-22.75	-12.84	31	< .001

The paired-samples t-test revealed a statistically significant difference between students' pretest and posttest scores, $t(31) = -12.84$, $p < .001$. Therefore, the null hypothesis stating that there was no significant difference between students' learning outcomes before and after the use of the Ethnomathematics Smart Box was rejected.

The substantial difference between the two measurements indicates that the implementation of the Smart Box was associated with significant improvement in students' learning outcomes. To complement the statistical significance analysis, the magnitude of the intervention effect was also estimated using effect size. The results indicated a large practical effect, suggesting that the observed improvement was not only statistically significant but also educationally meaningful.

Qualitative Findings from Classroom Implementation

Qualitative findings from observations and teacher interviews supported the quantitative results. Three major themes emerged during the implementation. **First**, students demonstrated improved spatial visualization. The ability to manipulate geometric nets allowed students to observe the process of transforming flat shapes into three-dimensional objects. This experience appeared to reduce the visualization difficulties identified during the preliminary analysis. **Second**, the cultural context increased the meaningfulness of mathematics learning. The introduction of Tegowangi Temple as a source of geometric exploration encouraged students to recognize that mathematical concepts could be found within their local cultural environment. Students were able to relate abstract geometric concepts to familiar visual and cultural contexts. **Third**, student engagement increased during hands-on activities. Compared with the preliminary classroom observations, students were more actively involved in exploring geometric models, discussing their findings with peers, and completing the activities in the student worksheets. Teachers also reported that the Smart Box helped maintain students' attention throughout the learning process.

Overall, the findings demonstrate that the Ethnomathematics Smart Box fulfilled the three primary quality criteria established in this study. The product was categorized as very valid based on expert assessment, very practical based on teacher and student responses, and effective in improving students' learning outcomes in three-dimensional geometry. The combination of interactive manipulation and local cultural context provided students with concrete and meaningful experiences for understanding abstract geometric concepts.

DISCUSSION

The findings of this study demonstrate that the Ethnomathematics Smart Box has the potential to provide a meaningful contribution to elementary school geometry learning. The developed medium was categorized as very valid based on expert assessment, highly practical according to teacher and student responses, and effective in improving students' learning outcomes in three-dimensional geometry. These findings suggest that the integration of manipulative learning media, hands-on activities, and local cultural contexts can address some of the fundamental difficulties experienced by elementary school students when learning abstract geometric concepts.

The Role of Hands-On Manipulation in Supporting Geometric Understanding

The improvement in students' learning outcomes can be attributed, in part, to the opportunity to manipulate geometric objects directly. Before the implementation of the Smart Box, students mainly encountered three-dimensional shapes as completed or ready-made objects. Although these objects could demonstrate the final form of a solid figure, they provided limited opportunities for students to understand how two-dimensional nets are transformed into three-dimensional structures.

The Ethnomathematics Smart Box addressed this limitation by allowing students to identify, disassemble, arrange, fold, and reconstruct geometric nets. Through these activities, students were not merely required to memorize the characteristics of three-dimensional shapes but were actively involved in constructing mathematical meaning. This process is particularly important because the understanding of spatial geometry requires students to coordinate two-dimensional and three-dimensional representations simultaneously.

The findings are consistent with previous research showing that students frequently experience difficulties when geometry instruction relies predominantly on abstract explanations or static representations.

Interactive and concrete representations can support students in understanding spatial relationships because they allow learners to observe and manipulate the structural components of geometric objects (10,17). Similarly, research on ethnomathematics-based and technology-supported learning media has demonstrated that interactive visualization can facilitate students' understanding of abstract geometric concepts and support spatial reasoning (21,22).

The present findings extend this perspective by demonstrating that physical manipulation does not necessarily require sophisticated digital technology. A well-designed manipulative medium can provide students with opportunities to engage in mental and physical transformations of geometric objects. When students construct a cube, rectangular prism, pyramid, or other three-dimensional object from a two-dimensional net, they experience the transformation process directly. This activity can reduce the gap between abstract mathematical representations and concrete spatial experiences.

The moderate N-gain obtained in this study further supports the educational value of this process. The improvement indicates that the Smart Box was capable of facilitating meaningful learning rather than simply increasing students' familiarity with test items. Nevertheless, the moderate category also suggests that students' understanding of spatial geometry develops progressively and may require repeated learning experiences. Therefore, the Smart Box should be considered not merely as a supplementary teaching aid but as a medium that can support systematic exploration and conceptual construction.

Ethnomathematics as a Context for Meaningful Geometry Learning

An important characteristic of the Ethnomathematics Smart Box is the integration of the Tegowangi Temple context into geometry learning. The results indicate that the use of local cultural heritage can make mathematical concepts more relevant to students' experiences. Before the implementation of the developed medium, students were unfamiliar with the geometric concepts embedded within Tegowangi Temple. This finding demonstrates a gap between the cultural environment surrounding students and the mathematical knowledge presented in formal classrooms.

Ethnomathematics provides an important framework for addressing this gap because it recognizes that mathematical ideas are embedded in cultural practices, artefacts, architecture, and everyday activities (5,6). Rather than presenting mathematics as an abstract and culturally neutral body of knowledge, ethnomathematics enables students to identify mathematical ideas within familiar social and cultural environments.

The Tegowangi Temple context was particularly relevant because architectural structures provide concrete examples of geometric forms. Cultural heritage can therefore function as more than an illustrative background in mathematics instruction. When systematically integrated into learning activities, cultural objects can become resources for identifying shapes, exploring spatial structures, and connecting mathematical concepts with students' local identities.

This finding is consistent with previous research on the exploration of ethnomathematical concepts in cultural artefacts and buildings. Geometric concepts have been identified in traditional architecture, cultural monuments, local crafts, and other community products (7,9,13). Recent studies also demonstrate that cultural heritage sites can provide concrete contexts for elementary students to identify two-dimensional and three-dimensional geometric concepts while simultaneously developing awareness of local cultural heritage (22).

The use of Tegowangi Temple in the present study also strengthens the pedagogical position of ethnomathematics. Culture was not included simply to increase the visual attractiveness of the learning media. Instead, cultural elements were integrated into the conceptual and instructional structure of the Smart Box. Students were encouraged to observe geometric forms, identify their characteristics, and subsequently reconstruct those concepts through hands-on activities.

This approach is important because meaningful contextualization requires more than presenting culturally familiar images alongside conventional mathematical exercises. The cultural context should function as an intellectual bridge between students' prior experiences and formal mathematical knowledge. In this study, Tegowangi Temple provided a context through which students could recognize that mathematical concepts are present within their surrounding environment.

Similar findings have been reported in recent studies on ethnomathematics-based geometry learning. Ethnomathematics-based instructional materials can make abstract geometric concepts more concrete and engaging because students are provided with contexts that are closer to their cultural experiences (23,24). Research has also shown that the integration of local cultural artefacts into geometry learning can improve students' engagement and facilitate connections between formal mathematical knowledge and everyday experiences (25).

Validity and Practicality of the Ethnomathematics Smart Box

The high validity score obtained from the expert evaluation indicates that the Ethnomathematics Smart Box fulfilled important requirements related to mathematical accuracy, instructional appropriateness, cultural relevance, visual design, and usability. The result demonstrates the importance of conducting systematic validation during the development of learning media.

A learning medium cannot be considered educationally appropriate solely because it is visually attractive or technologically innovative. The mathematical content must be accurate, the learning activities must correspond with instructional objectives, and the medium must be suitable for students' cognitive characteristics. In the present study, expert validation ensured that the Smart Box integrated these different dimensions before classroom implementation.

The very high validity results are consistent with recent studies developing ethnomathematics-based instructional media using systematic development models. For example, ethnomathematics-based media and modules developed through ADDIE or similar development procedures have generally demonstrated high levels of content and media validity when cultural contexts are carefully aligned with mathematical learning objectives (23,26). This indicates that the systematic integration of local culture into instructional design can produce educational products that are both culturally meaningful and mathematically appropriate.

The positive teacher and student responses also indicate that the Smart Box was practical for classroom use. Practicality is an important consideration because an instructional product may be theoretically valid but difficult to implement under actual classroom conditions. The positive responses in this study suggest that the components of the Smart Box, learning instructions, and student activities could be used effectively by the intended users.

From the teachers' perspective, the Smart Box provided structured activities that supported the explanation of abstract concepts. For students, the opportunity to interact directly with the learning components increased the attractiveness of mathematics learning. This finding supports the argument that learning media should be evaluated not only according to their theoretical quality but also according to their accessibility and usability in authentic educational settings.

Comparable findings have been reported in studies of ethnomathematics-based learning media. High practicality scores have been associated with the use of media that provide clear instructions, interactive activities, and culturally familiar contexts (26,27). Thus, the practicality of the Ethnomathematics Smart Box may be attributed to the combination of concrete manipulation and contextual relevance.

Improvement in Students' Learning Outcomes

The comparison between students' pretest and posttest scores showed a significant improvement in learning outcomes after the implementation of the Ethnomathematics Smart Box. The mean score increased substantially, while the paired-samples t-test indicated that the difference was statistically significant. These findings suggest that the learning activities implemented through the Smart Box were associated with positive changes in students' understanding of three-dimensional geometry.

The N-gain result, which was categorized as moderate, provides additional information regarding the magnitude of the improvement. The use of N-gain is important because a statistically significant difference does not necessarily indicate the practical magnitude of learning improvement. In this study, the moderate N-gain suggests that students experienced meaningful progress in understanding geometric concepts following the intervention.

The results are consistent with previous studies reporting positive effects of ethnomathematics-based learning on students' mathematical understanding. A recent meta-analysis of ethnomathematics-based geometry learning found an overall large positive effect on students' geometry understanding, suggesting that culturally contextualized learning can provide substantial educational benefits (26). However, the magnitude of improvement may vary according to the characteristics of the students, the type of cultural context, the mathematical topic, the duration of the intervention, and the quality of instructional implementation.

Previous studies have also demonstrated that ethnomathematics-integrated interactive media can improve mathematical learning outcomes. An ethnomathematics-based Android learning medium, for example, produced significant improvement in students' geometry-related problem-solving performance (25). Likewise, research on ethnomathematics-based learning materials in elementary schools has reported significant improvements between pretest and posttest performance (27).

Nevertheless, the findings of the present study should not be interpreted as evidence that cultural context alone was responsible for the improvement. The effectiveness of the Smart Box most likely resulted from the interaction of several instructional components. First, students were provided with concrete representations of abstract concepts. Second, they actively manipulated and reconstructed geometric objects. Third, the Tegowangi Temple context helped situate mathematical concepts within a meaningful cultural environment. Fourth, the learning activities encouraged active participation rather than passive reception of information. Therefore, the effectiveness of the Smart Box should be understood as the result of an integrated instructional design rather than a single pedagogical element.

Supporting Spatial Visualization and Active Learning

Spatial visualization is a fundamental component of learning three-dimensional geometry. Students are often required to imagine objects from different perspectives and mentally transform two-dimensional representations into three-dimensional structures. Such processes can be cognitively demanding, particularly for elementary school students who have limited experience with spatial manipulation.

The classroom observations in this study indicated that students became more actively engaged when they were able to manipulate geometric nets directly. The Smart Box transformed students from passive recipients of mathematical explanations into active participants who could explore and test their own understanding. Instead of being asked simply to identify the properties of a three-dimensional shape, students could physically examine the number of faces, edges, and vertices and observe the relationship between these components.

These findings are in line with studies emphasizing the importance of interactive representations for developing spatial abilities in geometry learning (21,24). Research on ethnomathematics-based spatial learning has similarly demonstrated that culturally contextualized representations can enhance students' engagement and spatial reasoning when combined with active exploration (22).

The active learning process may also explain the positive student responses to the Smart Box. Hands-on activities create opportunities for discussion, experimentation, and collaborative problem-solving. Students can compare different geometric constructions, identify mistakes, and reconstruct objects when necessary. These activities may support deeper conceptual understanding because students are involved in the process of constructing rather than merely receiving mathematical knowledge.

Implications for Mathematics Teaching

The findings have several implications for elementary mathematics instruction. First, teachers should provide students with opportunities to manipulate and explore geometric objects rather than relying exclusively on verbal explanations and static visual representations. The transition from concrete experiences to abstract mathematical representations is particularly important in the learning of three-dimensional geometry.

Second, local cultural heritage can serve as a meaningful source for mathematics learning. Cultural objects and environments surrounding students contain numerous mathematical concepts that can be explored systematically. Teachers can therefore develop learning activities that connect curriculum objectives with local contexts without sacrificing mathematical rigor.

Third, the development of learning media should consider the balance between innovation and usability. Educational innovation does not necessarily require complex digital technology. A physical manipulative medium such as the Smart Box can be pedagogically valuable when it is systematically designed, validated, and aligned with students' learning needs.

Finally, the integration of culture into mathematics education can contribute to broader educational objectives. In addition to improving cognitive learning outcomes, culturally contextualized learning may encourage students to appreciate local heritage and recognize the relevance of mathematics in their social and cultural environments.

Limitations and Future Research

Despite the positive findings, several limitations should be acknowledged. First, the effectiveness testing used a one-group pretest-posttest design. Without a comparison group, it is not possible to conclude definitively that the improvement in learning outcomes was caused exclusively by the Ethnomathematics Smart Box. Other factors, including repeated exposure to the learning content and classroom interactions, may have contributed to the observed improvement.

Second, the study involved participants from a limited educational context. The findings should therefore be interpreted cautiously and should not be generalized automatically to students in different regions or educational settings.

Third, the present study focused primarily on learning outcomes related to three-dimensional geometry. Although classroom observations suggested improvements in engagement and spatial visualization, these variables were not measured using separate standardized instruments. Future research should therefore investigate the effects of the Smart Box on spatial reasoning, mathematical motivation, mathematics anxiety, and cultural appreciation using more comprehensive measurement instruments.

Future studies should also employ quasi-experimental or experimental designs involving control groups and larger samples. Such studies would provide stronger evidence regarding the comparative effectiveness of ethnomathematics-based manipulative media. Longitudinal research would also be valuable for determining whether the conceptual understanding developed through the Smart Box is retained over time.

Overall Interpretation

Overall, the findings indicate that the Ethnomathematics Smart Box represents a promising approach to elementary geometry learning. Its effectiveness appears to result from the integration of three complementary elements: concrete manipulation, active hands-on learning, and culturally meaningful mathematical contexts. The Smart Box enabled students to transform geometric concepts from abstract objects of memorization into structures that could be explored, constructed, and connected with their cultural environment.

The results therefore support the broader proposition that effective mathematics learning should not be separated from students' concrete experiences and cultural contexts. When students are provided with opportunities to manipulate mathematical objects and explore the mathematics embedded within their cultural heritage, abstract concepts can become more accessible and meaningful. Within the context of this study, Tegowangi Temple served not only as a representation of local identity but also as an educational resource through which students could develop a deeper understanding of three-dimensional geometry.

The Ethnomathematics Smart Box consequently offers both a practical instructional contribution and a conceptual contribution to mathematics education. Practically, it provides teachers with an interactive medium for teaching three-dimensional geometry. Conceptually, it demonstrates how local cultural heritage can be systematically transformed into a meaningful resource for mathematical learning.

CONCLUSION

This study developed an Ethnomathematics Smart Box as an interactive learning medium for improving elementary school students' understanding of three-dimensional geometry. The development integrated hands-on learning activities with ethnomathematical contexts derived from Tegowangi Temple, enabling students to explore, manipulate, construct, and reconstruct geometric forms while connecting mathematical concepts with their local cultural heritage. The findings indicate that the developed Smart Box fulfilled the criteria of validity, practicality, and effectiveness. Expert validation demonstrated that the medium was highly appropriate in terms of mathematical content, instructional design, cultural relevance, and usability. Furthermore, positive responses from teachers and students indicated that the Smart Box was practical and feasible for implementation in elementary mathematics classrooms.

The implementation results also revealed an improvement in students' learning outcomes after using the Ethnomathematics Smart Box. The increase in posttest scores, the moderate N-gain, and the statistically significant difference between pretest and posttest results suggest that the medium effectively supported students' understanding of three-dimensional geometric concepts. The hands-on manipulation of geometric nets enabled students to develop a more concrete understanding of the relationship between two-dimensional representations and three-dimensional objects. Beyond cognitive learning outcomes, the integration of Tegowangi Temple into the learning activities demonstrated the potential of local cultural heritage as a meaningful resource for mathematics education. The cultural context helped students recognize that mathematical concepts are embedded within their surrounding environment, thereby making

abstract geometry more relevant and meaningful.
Overall, the Ethnomathematics Smart Box represents a promising approach for elementary geometry instruction by integrating concrete manipulation, active learning, and culturally contextualized mathematics. The findings suggest that learning media grounded in local cultural heritage can support both mathematical understanding and students' appreciation of their cultural environment. Nevertheless, this study was limited by the use of a one-group pretest-posttest design and a relatively limited research context. Future research should involve larger and more diverse samples, employ comparison or control groups, and examine the long-term effects of the Ethnomathematics Smart Box on students' spatial reasoning, mathematical motivation, mathematics anxiety, and cultural appreciation. Such investigations would provide stronger evidence regarding the broader effectiveness and sustainability of ethnomathematics-based learning media in mathematics education.

Declaration by Authors

Acknowledgement: None
Source of Funding: None
Conflict of Interest: No conflicts of interest declared.

REFERENCES

1. Praja NA, Susilo BE. Systematic Literature Review: Efektifitas Problem-Based Learning Berbantuan Media Pembelajaran terhadap Literasi Matematis Siswa Indonesia. Symmetry: Pasundan Journal of Research in Mathematics Learning and Education. 2025 Dec 31;10(2):164-79. https://doi.org/10.23969/symmetry.v10i2.35653
2. Aniyawati RS, Dewi NK, Ayuningtyas DM. PENERAPAN MEDIA SMART BOX UNTUK MENINGKATKAN HASIL BELAJAR PPKN MATERI KEBERAGAMAN SEBAGAI KEKUATAN SISWA KELAS V SD. Jurnal Media Akademik (JMA). 2024 Oct 30;2(10). https://doi.org/10.62281/v2i10.856
3. Anugraini AP, Rachmawati YS. PENGEMBANGAN MEDIA PEMBELAJARAN MATEMATIKA BERBASIS ADOBE FLASH DI SEKOLAH DASAR. Jurnal Ilmiah Matematika Realistik (JI-MR). 2025 Dec;6(2):350-6. http://jim.teknokrat.ac.id/index.php/pendidikanmatematika/index
4. Dewi SK, Sulistyono BA, Samijo S. Peran Media Pembelajaran Interaktif PATRIKS dalam Meningkatkan Motivasi Siswa. Polinomial: Jurnal Pendidikan Matematika. 2025 Aug 10;4(3):554-62. https://doi.org/10.56916/jp.v4i3.2023
5. Apiati V, Heryani Y, Siska D, Muslim R. Etnomatematik dalam bercocok tanam padi dan kerajinan anyaman masyarakat Kampung Naga. Mosharafa. 2019;8(1). https://doi.org/10.31980/mosharafa.v8i1.539
6. Puspasari PR, Rinawati A, Pujisaputra A. Aspek matematis pada aktivitas etnomatematika produksi ecoprint di Butik El Hijaaz. Mosharafa. 2021;10(3). https://doi.org/10.31980/mosharafa.v10i3.670
7. Nurdiansyah S, Sundayana R, Sritresna T. Kemampuan berpikir kritis matematis serta habits of mind menggunakan model inquiry learning dan model creative problem solving. Mosharafa: jurnal pendidikan matematika. 2021 Jan 30;10(1):95-106. https://doi.org/10.31980/mosharafa.v10i1.644
8. Nur A. Literature review: Pengaruh kecemasan matematika (math anxiety) terhadap kemampuan literasi numerasi siswa sekolah dasar. J Inov Edukasi. 2024;7(2).
9. Wijaya BC, Amanda YR, Rahmatul HL, Samijo S, Jatmiko J. Studi Etnomatematika: Bentuk Bangun Datar dan Bangun Ruang pada Monumen Simpang Lima Gumul. Dharma Pendidikan. 2025 Apr 28;20(1):14-20. https://doi.org/10.69866/dp.v20i1.558
10. Rahmawati N, Santia I, Hima LR, Handayani AD. Potensi etnomatematika

berbasis budaya kediri sebagai konteks pembelajaran geometri: Systematic literature review. Jurnal Math Educator Nusantara: Wahana Publikasi Karya Tulis Ilmiah di Bidang Pendidikan Matematika. 2026 May 31;12(1):172-92. https://doi.org/10.29407/jmen.v12i1.28723
11. Putri RII, Somakim, Negara JS. Etnomatematika: Pengenalan bangun datar melalui konteks Museum Negeri Sumatera Selatan Balaputera Dewa. Mosharafa. 2020;9(3). https://doi.org/10.31980/mosharafa.v9i3.618
12. Khalif MI, Prabowo LE. Penerapan Model Algoritma Unsupervised Learning untuk Klasterisasi Tingkat Kenyamanan Ruang Tidur berdasarkan Faktor Lingkungan. Jurnal Teknologi Informasi dan Ilmu Komputer. 2025 Apr 24;12(2):311-20. https://doi.org/10.25126/jtiik.2025129456
13. Septiarani D, widi Tinawa J, Jatmiko J. Eksplorasi etnomatematika pada ornamen candi Tegowangi dalam pembelajaran geometri. Dharma Pendidikan. 2025 Apr 28;20(1):40-9. https://doi.org/10.69866/dp.v20i1.554.
14. Susanto A. Teori Belajar dan Pembelajaran di Sekolah Dasar. Jakarta: Kencana; 2016.
15. Gumala YG, Syifa MS. Media Pembelajaran Berbasis Etnomatematika Di Sekolah Dasar. Bersatu: Jurnal Pendidikan Bhinneka Tunggal Ika. 2025 Feb 24;3(1):32-45. https://doi.org/10.51903/bersatu.v3i1.892
16. Fitriyah AT, Syafi M. Etnomatematika pada Bale Lumbung Sasak. Mosharafa. 2022;11(1). https://doi.org/10.31980/mosharafa.v11i1.682
17. Wathoni N. Penggunaan media konkret dalam pembelajaran konsep matematika abstrak. Jurnal Ilmiah IPA Dan Matematika (JIIM). 2024 Nov 30;2(4):101-5. https://doi.org/10.61116/jiim.v2i4.484
18. Nugraha NW, Novaliyosi N. Media pembelajaran berbasis etnomatematika: systematic literature review. Jurnal Lebesgue: Jurnal Ilmiah Pendidikan Matematika, Matematika Dan Statistika. 2023 Apr 30;4(1):477-90.
19. Yuliani I, Prihaswati M, Mawarsari VD. Respon Penggunaan E-LKPD Berbasis STEM Kearifan Lokal Bernuansa Pendidikan Karakter Materi Lingkaran Kelas VIII. AKSIOMA: Jurnal Matematika dan Pendidikan Matematika. 2023 Sep 30;14(2):119-30. https://doi.org/10.26877/jipmat.v8i2.15489
20. Santi NN, Zaman WI. Analisis Implementasi Literasi Budaya dan Kewarganegaraan Terhadap Pendidikan Karakter Siswa kelas 5 SDN 1 Banjarsari. InProsiding SEMDIKJAR (Seminar Nasional Pendidikan dan Pembelajaran) 2025 Jul 19 (Vol. 8, pp. 250-260). https://doi.org/10.29407/hyca3534
21. Gustina DM, Mariana N, Wiryanto W. Augmented reality-based ethnomathematics learning media to enhance spatial ability in 3D geometry for fifth grade elementary students. Journal of Innovation and Research in Primary Education. 2025 Apr 29;4(2):273-80. https://doi.org/10.56916/jirpe.v4i2.1229
22. Putri NE, Mariana N, Cahapay MB. Ethnomathematics Exploration of Geometry Concepts for Grade V at the Surabaya Education Museum as a Cultural Heritage. Glocal Praxis in Elementary Education. 2026 Jul 5;2(1):54-69. https://journal.unesa.ac.id/index.php/GPrEEc
23. Istiningsih S, Dewi NK, Erfan M, Wulandari R. Development of a HOTS-Based Ethnomathematics Module of the Sasambo Tribe on Spatial Geometry for Elementary School Students. Jurnal Kependidikan: Jurnal Hasil Penelitian dan Kajian Kepustakaan di Bidang Pendidikan, Pengajaran, dan Pembelajaran. 2026 Mar 14;12(1):200-12. https://doi.org/10.33394/jk.v12i1.17112
24. Anggraini CCD, Wiradharma G, Prasetyo MA, Anam K. Evaluasi media pembelajaran augmented reality bangun datar/ruang dengan pendekatan etnomatematika Rumah Adat Lengkong dalam meningkatkan kemampuan spasial

siswa sekolah dasar. JOEAI. 2024;7(2). https://doi.org/10.31539/joeai.v7i2.12081
25. Hodiyanto H, Kyeremeh P, Susanti G, Aprida V, Hartono H. Development of ethnomathematics-integrated android-based media for enhancing problem-solving skills in secondary geometry learning. JRAMathEdu (Journal of Research and Advances in Mathematics Education). 2026 Jan 30:13-29. https://doi.org/10.23917/jramathedu.v11i1.13730
26. Leu TM, Koli RB, Mbuik HB. PENGEMBANGAN BUKU AJAR ETNOMATEMATIKA BERBASIS TENUN MABUNE PADA MATERI BANGUN DATAR UNTUK SISWA KELAS IV SEKOLAH DASAR. Pendas: Jurnal Ilmiah Pendidikan Dasar. 2026 Jul 8;11(03):397-420. https://doi.org/10.23969/jp.v11i03.56304
27. Istia MS, Mumu J, Matunubun LKD. Meta-analysis of ethnomathematics based geometry learning in Indonesian junior high schools. Media Pendidikan Matematika. 2026;13(2). https://doi.org/10.33394/mpm.v13i2.18373

How to cite this article: Ika Santia, Samijo, Wahid Ibnu Zaman. Development of "smart box" ethnomathematics media to improve students' learning outcomes regarding 3D shapes. *International Journal of Research and Review*. 2026; 13(9): 189-206. DOI: *https://doi.org/10.52403/ijrr.20260921*

******