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Developing an Osing House Ethnomathematics-Based LKPD to Strengthen Elementary Students' Understanding of Flat Shape Areas

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Abstract

Learning the area of flat shapes in elementary school remains difficult when instruction begins with formulas and gives students limited opportunities to construct the meaning of area through concrete, visual, and contextual experiences. This study aimed to develop and examine the validity and limited-trial usability of an ethnomathematics-based student worksheet (LKPD) grounded in the geometric elements of traditional Osing houses for fifth-grade elementary students. The study employed a Research and Development approach using the ADDIE model: Analysis, Design, Development, Implementation, and Evaluation. Participants were selected purposively and consisted of three validators—a mathematics education expert, a learning media expert, and an Osing cultural expert—one fifth-grade teacher, and twelve fifth-grade students. Data were collected through expert-validation sheets, teacher practicality responses, student-response questionnaires, observation notes, and interviews. Quantitative data were analyzed using percentage scores and predetermined validity criteria, while qualitative comments were analyzed thematically to identify revision priorities. The analysis stage identified the need for concrete representations, prerequisite review, cultural authenticity, and gradual conceptual scaffolding. The developed LKPD organized learning activities from observing Osing house structures and identifying flat shapes to exploring unit-square area, deriving formulas, and solving composite-shape problems. Validation results reached 90.38% for subject matter, 93.75% for learning media, and 96.87% for cultural relevance, all categorized as highly valid. Limited-trial feedback led to revisions in instructions, visual consistency, prerequisite concepts, and the transition from unit-grid counting to formula use. The findings indicate that the revised LKPD is pedagogically coherent, culturally appropriate, and suitable for wider classroom implementation and subsequent effectiveness testing.

Keywords: ethnomathematics; Osing house; student worksheet; flat shape area; elementary mathematics

Introduction

Geometry is a central component of elementary mathematics because it develops students' spatial reasoning, measurement sense, visualization, and ability to interpret the physical environment. Among geometry topics, the area of flat shapes is conceptually important because it connects counting, multiplication, measurement, unit iteration, decomposition, and proportional reasoning. Nevertheless, many elementary students treat area formulas as rules to memorize rather than generalizations derived from measurable attributes. They may correctly recite a formula but still confuse area with perimeter, fail to explain why square units are used, or have difficulty decomposing composite figures. Research on children's area measurement shows that conceptual development depends on coordinating equal units, rectangular arrays,

and multiplicative structure rather than merely recalling length × width (Kamii & Kysh, 2006; Outhred & Mitchelmore, 2000). Such difficulties frequently arise when classroom instruction moves too quickly from pictures to symbolic procedures without allowing students to build the concept through unit squares, comparison, rearrangement, and contextual problem solving (Juliangkary et al., 2024; Mulligan, 2025; Winarti et al., 2025).

Instructional materials have a strategic role in reducing this conceptual gap. A student worksheet is not merely a collection of exercises; when designed systematically, it can guide observation, questioning, representation, exploration, calculation, and reflection. For area learning, an effective worksheet should sequence activities from recognizing the measured attribute, selecting and iterating equal units, covering a region without gaps or overlaps, counting unit squares, relating repeated addition to multiplication, and finally constructing formulas for simple and composite shapes. This sequence is consistent with learning-trajectory perspectives that place concrete and visual activity before increasingly abstract mathematical representations (Clements & Sarama, 2014). If these stages are absent, students can become procedurally competent while retaining weak conceptual understanding. Therefore, the design of LKPD should integrate clear instructions, visual representations, graduated scaffolding, and contextual tasks that are meaningful to students.

Ethnomathematics provides a relevant framework for developing contextual mathematics materials. It recognizes that mathematical ideas are embedded in cultural practices, artifacts, architecture, crafts, games, spatial arrangements, and community problem-solving activities. D'Ambrosio (1985) established ethnomathematics as a way of examining the mathematical knowledge produced within identifiable cultural groups, while Bishop (1988) explained mathematics learning as a process of enculturation. Later scholarship emphasized that ethnomathematics can support culturally responsive pedagogy when cultural knowledge is connected critically and accurately to formal mathematical concepts (Presmeg, 1998; Rosa & Orey, 2011). In education, ethnomathematics does not replace formal mathematics; rather, it creates a bridge between students' cultural environment and disciplinary concepts. Prior studies report that ethnomathematics-based learning can strengthen mathematical literacy, conceptual understanding, motivation, identity, and contextual problem solving (Pratama & Yelken, 2024; Sari et al., 2022; Turmuzi et al., 2023; Wulandari et al., 2024).

Traditional houses are particularly rich ethnomathematical resources because their roofs, walls, floors, ornaments, doors, windows, and spatial layouts contain geometric patterns and measurement relationships. Studies of Indonesian traditional architecture have documented plane figures, symmetry, transformations, measurement, and spatial relations that can be translated into contextual geometry tasks (Sari et al., 2022; Supiyati et al., 2023). The traditional Osing house of Banyuwangi represents local knowledge through architectural forms, spatial organization, construction traditions, and cultural meanings. Rectangular and square wall sections, triangular and trapezoidal roof components, repeated ornament patterns, and composite floor layouts can be transformed into learning contexts for identifying shapes and exploring area. However, cultural integration must be handled carefully. Using an image of a traditional house merely as decoration does not constitute meaningful ethnomathematics. The cultural element should function as a source of mathematical observation, a context for problem formulation, and an object of reflection, while its description remains accurate and respectful.

Existing ethnomathematics research has often concentrated on identifying mathematical concepts within cultural artifacts. This descriptive work is valuable, but classroom implementation requires an additional design step: translating cultural findings into a structured learning product with explicit objectives, age-appropriate language, valid mathematical content, authentic cultural representation, and a coherent activity sequence. Reviews of Indonesian

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ethnomathematics research similarly indicate that exploration studies remain more common than validated instructional products and systematic classroom testing (Iskandar et al., 2023; Turmuzi et al., 2023). Studies that transform the geometric elements of traditional Osing houses into a validated, classroom-oriented LKPD for fifth-grade area learning therefore remain limited. The present study addresses this need by positioning Osing house architecture not only as an illustration but as the principal contextual source from which students observe, identify, measure, calculate, and reflect.

The originality of the developed product lies in three features. First, the LKPD uses selected Osing house elements as an organizing context across the learning sequence rather than as an isolated opening picture. Second, it scaffolds conceptual development from shape recognition and unit-square exploration to formula construction and composite-area problem solving. Third, it includes cultural reflection so that students understand both the mathematical and local-heritage significance of the activities. This combination is expected to support conceptual access while introducing students to the cultural environment of Banyuwangi.

Based on the identified gap, the study addressed the following research question: How can an ethnomathematics-based LKPD rooted in traditional Osing houses be developed to strengthen elementary students' understanding of flat shape area concepts? More specifically, the study sought to describe the development process, determine the product's validity in terms of subject matter, learning media, and cultural relevance, and identify revisions arising from a limited trial. The study did not test causal effectiveness; its focus was product development, expert validation, and initial usability evidence as prerequisites for broader field testing.

Method

Research Design

This study employed a Research and Development (R&D) approach to produce an ethnomathematics-based LKPD grounded in the geometric elements of traditional Osing houses. The development procedure followed the ADDIE model, consisting of Analysis, Design, Development, Implementation, and Evaluation (Branch, 2009; Molenda, 2015). ADDIE was selected because it provides a systematic yet iterative structure for aligning learner needs, curriculum requirements, product design, expert review, trial implementation, and revision. Its iterative logic is also compatible with educational design research, in which prototypes are progressively refined through analysis, formative evaluation, and empirical feedback (Plomp, 2013; Plomp & Nieveen, 2013). Formative evaluation occurred throughout all stages, while summative evaluation at this phase was limited to the synthesis of validation and limited-trial results.

The product was designed for the fifth-grade elementary mathematics topic of flat shape area under Phase C of the Merdeka Curriculum. The development emphasized conceptual understanding rather than formula rehearsal. Accordingly, the worksheet activities were designed to help students recognize geometric forms, interpret area as the amount of surface covered, use unit squares, connect counting with multiplication, calculate simple areas, decompose composite shapes, and explain solutions in contextual terms.

Participants and Setting

Participants were selected through purposive sampling because each participant had a specific role in evaluating the product. The expert-validation group consisted of one mathematics education expert, one learning media expert, and one Osing cultural expert. Their expertise was required to assess mathematical accuracy, curriculum alignment, instructional design, visual communication, cultural authenticity, and appropriateness. The limited trial

involved one fifth-grade teacher and twelve fifth-grade students. The small group was used to identify readability problems, unclear instructions, visual difficulties, misconceptions, and practical barriers before a wider implementation. Participation was voluntary, and student feedback was reported in aggregate without identifying individuals.

ADDIE Development Procedures

During the analysis stage, the researchers conducted curriculum analysis, student-needs analysis, student-characteristic analysis, and cultural-object analysis. Curriculum analysis examined the alignment of the area topic with Phase C learning outcomes involving measurement, reasoning, representation, and problem solving. Student-needs analysis focused on common difficulties in distinguishing area from perimeter, understanding square units, moving from unit-square counting to formulas, and solving composite figures. Student-characteristic analysis considered fifth graders' need for concrete and visual representations before symbolic abstraction. Cultural-object analysis identified selected geometric forms in Osing house roofs, walls, doors, windows, ornaments, floor plans, and spatial layouts.

During the design stage, the researchers specified learning objectives, selected Osing house elements, prepared the LKPD framework, sequenced activities, drafted instructions, planned visual layouts, and developed research instruments. The worksheet was divided into two major topics. Topic 1 emphasized observing Osing house structures, identifying flat shapes, and describing side, angle, and vertex characteristics. Topic 2 emphasized area exploration through unit grids, formula construction, calculation of simple shapes, and decomposition of composite forms. Each topic followed an observe–identify–analyze–experiment–solve–reflect sequence.

During the development stage, the first prototype was produced and submitted to expert validation. The prototype contained a cover, learning objectives, instructions, contextual information about Osing houses, observation tasks, shape-identification tables, unit-grid activities, area problems, composite-shape tasks, and reflection prompts. Expert comments were compiled into a revision matrix. Revisions were prioritized when they concerned mathematical correctness, possible student misunderstanding, instructional clarity, or cultural inaccuracy. Minor editorial and visual suggestions were also addressed to improve consistency.

During the implementation stage, the revised prototype was used in a limited trial with one teacher and twelve students. The teacher facilitated the activities while the researchers observed how students interpreted instructions, used illustrations, completed unit-grid tasks, and moved toward formula-based calculation. Brief interviews and response sheets were used after the activity. The purpose was not to estimate learning effectiveness but to obtain initial evidence of readability, practicality, engagement, and conceptual accessibility.

During the evaluation stage, quantitative validation scores and qualitative feedback were synthesized. Formative evaluation was embedded in each stage through repeated checking of objectives, content, layout, and cultural descriptions. The final revision addressed three main areas: prerequisite concepts, clarity and consistency of instructions, and the conceptual bridge between cultural forms, unit-square exploration, and formula use.

Instruments and Data Analysis

Data were collected through expert-validation sheets, a teacher practicality-response sheet, a student-response questionnaire, observation notes, and semi-structured interviews. The subject matter validation sheet assessed content accuracy, curriculum alignment, conceptual coherence, difficulty level, and problem suitability. The learning media sheet assessed layout, typography, illustration quality, instruction clarity, activity sequencing, and usability. The cultural validation sheet assessed authenticity, terminology, appropriateness, and the relevance of selected Osing house elements to the mathematical content. Teacher and student instruments focused on readability, attractiveness, clarity, ease of use, and perceived usefulness.

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Expert-validation items used a four-point Likert scale. The validity percentage was calculated using P = (obtained score / maximum score) × 100%. The interpretation criteria were 85.01–100% = highly valid, 70.01–85.00% = valid, 50.01–70.00% = less valid, and ≤50.00% = invalid. These percentage criteria were used as product-development decision rules rather than as substitutes for psychometric validity coefficients. Student responses used Yes/No options, while teacher responses and observation notes were interpreted descriptively. Qualitative comments were coded by source and grouped into themes such as content sequence, instruction clarity, visual consistency, cultural accuracy, and scaffolding. The integration of quantitative and qualitative evidence was used to determine whether the product was ready for wider testing and what revisions were necessary before that stage.

Results

The development process produced an ethnomathematics-based LKPD for flat shape area learning rooted in the geometric elements of traditional Osing houses. To make the findings transparent, the results are organized into five subthemes: development needs, product design, prototype characteristics, expert-validation findings, and limited-trial revisions.

Finding 1: Students Needed a Concrete and Gradual Route to Area Concepts

The analysis stage identified four interrelated development needs. First, students required concrete representations to understand area as surface coverage rather than as a formula detached from meaning. Unit-square counting was therefore positioned as the conceptual starting point. Second, students needed a short review of prerequisite geometry concepts-sides, angles, vertices, and the characteristics of common flat shapes-before they could analyze area. Third, the curriculum required tasks that combined measurement, reasoning, representation, and problem solving instead of routine calculation only. Fourth, students needed visual and contextual stimuli that could help them discuss geometric forms before using mathematical symbols.

The cultural-object analysis identified rectangles, squares, triangles, trapezoids, and composite forms in selected Osing house structures. These elements were mapped to specific learning objectives. Rectangular wall and floor sections were used for basic area exploration; triangular and trapezoidal roof elements supported shape recognition and comparison; and combined roof or floor-plan representations supported decomposition of composite figures. This mapping prevented the cultural context from being used merely as decoration and ensured that every selected element had a clear mathematical function.

Finding 2: The LKPD Was Structured Around Two Connected Learning Topics

The design stage produced an LKPD organized into two connected topics. Topic 1 focused on observing traditional Osing house structures, locating geometric forms, naming shapes, and describing their characteristics. Students were asked to mark or trace shapes, complete comparison tables, and explain which structural elements resembled particular flat shapes. These activities were intended to activate prior knowledge and establish a shared visual vocabulary.

Topic 2 focused on the concept and calculation of area. Students first covered or interpreted regions using unit grids, counted square units, and compared regions with different orientations. They then related repeated rows and columns to multiplication and derived the formulas for rectangles and squares. The next activities required students to calculate areas of selected house components and solve composite-shape problems by decomposing the figure into familiar shapes. Reflection prompts asked students to explain what mathematical ideas they discovered and how the Osing house context contributed to their understanding.

The activity sequence followed six recurring actions: observing, identifying, analyzing, experimenting, solving, and reflecting. This sequence gave the LKPD an inquiry-oriented structure while remaining suitable for guided elementary instruction. It also allowed each activity to prepare students for the next, reducing abrupt transitions from cultural observation to symbolic calculation.

Finding 3: The Prototype Integrated Cultural Information, Visual Tasks, and Mathematical Scaffolding



Figure 1. Cover Design of the Osing House Ethnomathematics-Based LKPD

The first prototype included a cover, learning identity, learning objectives, instructions, contextual reading, observation illustrations, tables for identifying shape characteristics, unit-grid explorations, worked examples, independent and group tasks, composite-area exercises, and reflection questions. Osing house visuals were placed at points where students needed to observe or interpret a geometric element, rather than being repeated as ornamental background images.

The prototype also incorporated scaffolding questions. For example, before students used a rectangle formula, they were asked how many unit squares appeared in one row, how many rows were present, and how repeated addition could be written as multiplication. Before solving a composite figure, they were asked to draw partition lines, name the resulting simple shapes, calculate each part, and combine the results. These prompts were designed to make reasoning visible and to help teachers diagnose where students experienced difficulty.

Finding 4: Expert Validation Confirmed High Content, Media, and Cultural Validity

Three experts validated the prototype. The subject matter expert awarded 90.38%, the learning media expert awarded 93.75%, and the Osing cultural expert awarded 96.87%. All scores fell within the highly valid category. Table 1 summarizes the assessment results and the function of each data source.

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Table 1. Results of Expert Validation and Limited-Trial Data Sources

Assessment aspect	Assessor/respondent	Score (%)	Category/use
Subjectmatter validation	Mathematics education expert	90.38	Highly valid
Learning media validation	Learning media expert	93.75	Highly valid
Cultural relevance validation	Osing cultural expert	96.87	Highly valid
Limited practicality feedback	One fifth-grade teacher	Qualitative	Product revision
Student response in limited trial	Twelve fifth-grade students	Qualitative	Readability and usability feedback
Subject matter validation	Mathematics education expert	90.38	Highly valid

The subject matter expert judged the content, curriculum alignment, and overall sequence to be appropriate but recommended a stronger transition from recognizing shape elements to calculating area. In response, prerequisite review items and intermediate questions were added. The expert also advised ensuring that composite-area problems progressed from simple partitioning to more demanding configurations.

The learning media expert considered the layout and activity organization highly suitable but identified several long instructions and inconsistent visual placements. The revision shortened sentences, converted multi-step instructions into numbered actions, standardized heading levels, and improved spacing between illustrations, questions, and response areas. The goal was to reduce extraneous cognitive load and make the worksheet easier to use with limited teacher explanation.

The cultural expert gave the highest score and confirmed that the selected Osing house elements were relevant. Nevertheless, the expert recommended clarifying cultural descriptions so that students would not interpret generalized architectural illustrations as exact representations of every Osing house. The revised text therefore distinguished between selected representative elements and the diversity of actual houses. Cultural terminology was checked, and descriptions that did not contribute to the learning objective were removed or simplified.

Finding 5: Limited-Trial Feedback Clarified How Students Used the LKPD

The limited trial involved one fifth-grade teacher and twelve students. The teacher reported that the cultural images successfully attracted attention and initiated discussion, but students needed a concise review of sides, angles, and vertices before entering area tasks. The teacher also recommended additional examples showing how unit-square counting leads to multiplication. These suggestions were consistent with classroom observations.

Students generally identified rectangles, squares, and triangles in the illustrations with little difficulty. Trapezoidal and composite forms required more teacher prompts. During unit-grid activities, most students could count square units, but several initially counted boundary lines or treated partially visible units inconsistently. When the worksheet moved to formulas, some students attempted to use a memorized rule without referring to rows and columns. Additional questions were therefore inserted to explicitly connect the number of units in one row, the number of rows, and the multiplication expression.

The trial also showed that short, direct instructions were more effective than dense explanatory paragraphs. Students responded more consistently when one task required one clear action and when the expected answer space was visually obvious. Based on these findings, the final LKPD added prerequisite reminders, simplified wording, improved visual consistency, strengthened cultural explanations, and expanded scaffolding between concrete representations and formulas.

The final product consisted of activities for recognizing flat shapes in Osing house architecture, comparing shape characteristics, exploring area through unit grids, calculating simple areas, solving composite-shape problems, and writing a short reflection on the mathematical and cultural meaning of the activity. The revised sequence was judged suitable for wider classroom implementation and effectiveness testing.

Discussion

The results indicate that the Osing house ethnomathematics-based LKPD achieved high validity across subject matter, learning media, and cultural relevance. This finding is important because a culturally contextual product must satisfy more than one quality dimension. Mathematical correctness alone is insufficient when instructions are difficult to follow or cultural information is inaccurate. Conversely, attractive cultural content cannot compensate for weak conceptual sequencing. The combined validation evidence suggests that the product achieved an acceptable balance among disciplinary accuracy, instructional usability, and cultural appropriateness.

The subject matter score of 90.38% supports the suitability of the mathematical content and learning sequence for fifth-grade area instruction. The strongest conceptual feature was the progression from visual recognition to unit-area exploration, formula construction, and composite-shape problem solving. This progression reflects evidence that children must coordinate equal-sized units, rows and columns, and multiplicative relationships before a rectangular-area formula becomes meaningful (Kamii & Kysh, 2006; Outhred & Mitchelmore, 2000). It also reflects the principle that elementary students require visual-spatial and measurement experiences before they can generalize symbolic formulas (Clements & Sarama, 2014; Mulligan, 2025; Winarti et al., 2025). By asking students to count units, examine rows and columns, and then express the relationship multiplicatively, the LKPD makes the origin of the formula visible rather than presenting length × width as an unexplained rule.

The validation and trial findings also emphasize the role of prerequisite knowledge. Students cannot reason effectively about area if they do not reliably recognize shape characteristics or distinguish the boundary of a region from the region itself. The teacher's request for a brief review of sides, angles, and vertices was therefore not an additional topic unrelated to area; it was a necessary scaffold. The revised LKPD treats prerequisite review as diagnostic preparation and then connects it directly to later measurement tasks. This supports a coherent conceptual trajectory rather than fragmented worksheet activities.

The learning media score of 93.75% reflects the overall suitability of the structure, instructions, and visual presentation. In worksheet-based learning, usability is critical because students interact directly with printed or digital prompts, response spaces, illustrations, and examples. A mathematically correct activity can fail if instructions contain multiple actions, if visual cues are inconsistent, or if students cannot determine where to write. The limited trial confirmed this point: students performed more consistently when tasks were broken into concise steps and when the relationship between an image and its question was visually clear.

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The revision of wording and layout therefore functioned as an instructional intervention, not merely an editorial improvement.

The cultural validation score of 96.87% indicates that the Osing house context was considered relevant and appropriate. This result supports the central premise of the study: local architecture can function as a meaningful source of mathematical exploration. The LKPD did not simply place cultural images around conventional exercises. Instead, selected house elements generated the observation tasks, shape-identification activities, area problems, and reflection questions. This is consistent with foundational views that mathematical knowledge is culturally situated and that mathematics education involves forms of enculturation (Bishop, 1988; D'Ambrosio, 1985). It also aligns with secondary scholarship on culturally responsive ethnomathematics (Presmeg, 1998; Rosa & Orey, 2011) and empirical studies showing the educational potential of traditional houses and local artifacts for geometry learning (Sari et al., 2022; Supiyati et al., 2023; Turmuzi et al., 2023).

At the same time, the cultural expert's comments highlight an essential safeguard. Cultural representation must avoid oversimplification. Traditional architecture is diverse, historically situated, and connected to community meaning. A worksheet necessarily selects and simplifies visual elements, but it should state that these are representative learning objects rather than exhaustive definitions of Osing architecture. The revision therefore improved terminology and contextual explanations while keeping the language appropriate for elementary students. This approach strengthens cultural respect and prevents ethnomathematics from becoming superficial decoration.

The limited trial provided initial evidence that contextual images supported shape identification and classroom discussion. Students could connect abstract shape names with visible house components, which made the starting point of geometry learning more concrete. However, the trial also showed that context alone does not guarantee conceptual understanding. Several students still needed explicit guidance to move from counting unit squares to using formulas. This finding demonstrates that ethnomathematical context and mathematical scaffolding are complementary. The cultural object creates relevance and a visual anchor, while carefully sequenced questions support abstraction. Comparable Indonesian research also indicates that local-wisdom-based media are most useful when cultural contexts are integrated with explicit problem-solving processes and structured mathematical tasks (Waliah et al., 2026).

Compared with studies that primarily document mathematical concepts in cultural artifacts, the present study contributes a validated instructional prototype. The product translates cultural analysis into objectives, tasks, illustrations, prompts, and assessment opportunities. This translation is the practical contribution of the research. It moves from identifying mathematics in culture to designing mathematics learning through culture. The LKPD may also support cultural awareness because students are invited to interpret local architecture as a knowledge-rich environment rather than as a static heritage image.

The study has several implications for teachers and instructional-material developers. First, cultural contexts should be selected according to their conceptual relevance, not simply their visual appeal. Second, activities should make the mathematical transition from concrete representation to symbolic procedure explicit. Third, expert validation should include both cultural and pedagogical expertise. Fourth, limited trials remain necessary even when validation scores are high because students may interpret instructions and representations differently from adult experts. Finally, reflection activities can help students articulate the relationship between mathematics and local knowledge.

This study has several limitations. The implementation involved only one teacher and twelve students, so the findings cannot be generalized to wider populations. The study focused

on validity and initial usability rather than effectiveness; no pretest–posttest comparison or control group was used. The selected Osing house representations covered only certain architectural and ornamental elements, and the prototype addressed one geometry topic. In addition, the response data were primarily descriptive, and the use of single validators for each expertise domain limits the stability of the validation evidence. Future research should involve a larger and more diverse sample, include multiple validators per domain, report inter-rater or content-validity indices where appropriate, examine reliability and practicality quantitatively, and test learning outcomes through experimental or quasi-experimental designs. Further development could include digital interactive versions, teacher guides, differentiated tasks, and additional topics such as perimeter, symmetry, scale, and spatial reasoning.

Conclusion

This study developed an ethnomathematics-based LKPD grounded in the geometric elements of traditional Osing houses for fifth-grade flat shape area learning. The product was developed systematically through the ADDIE stages of analysis, design, development, implementation, and evaluation. It integrated Osing house structures into activities for identifying flat shapes, reviewing prerequisite concepts, exploring area through unit grids, deriving formulas, calculating simple and composite areas, and reflecting on the relationship between mathematics and local culture.

Expert validation showed that the LKPD was highly valid, with scores of 90.38% for subject matter, 93.75% for learning media, and 96.87% for cultural relevance. Feedback from one teacher and twelve students led to revisions in prerequisite explanations, instruction clarity, visual consistency, cultural description, and conceptual scaffolding. These results indicate that the revised LKPD is appropriate for broader classroom implementation. Claims about effectiveness, however, require subsequent testing with a larger sample and a comparative design.

Declarations

Ethics statement: Participation was voluntary, student responses were reported in aggregate, and no personally identifiable information was disclosed.
Conflict of interest: The authors declare no conflict of interest.
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Author contributions: Ilfi Nur Diana conducted the investigation, developed the product, collected and analyzed the data, and drafted the manuscript. Oktaviani Adhi Suciptaningsih and Aynin Mashfufah supervised the study, contributed to the methodology and validation framework, and critically reviewed the manuscript. All authors approved the final version.

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