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Development of a Geometry Module Based on Ethno–Collaborative Inquiry to Support Deep Learning Among Elementary School Students

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Abstract: This study aims to develop an Ethno–Collaborative Inquiry-Based Plane Figures Module to support deep learning among elementary school students. This study employed a Research and Development (R&D) approach using the ADDIE model, which comprised five stages: Analysis, Design, Development, Implementation, and Evaluation. The analysis stage was conducted to identify learning needs, student characteristics, curriculum requirements, and the potential of local ethnomathematics relevant to plane geometry. The design stage focused on developing the module structure, learning objectives, collaborative inquiry activities, learning materials, exercises, and evaluation instruments. The development stage involved producing the initial module and conducting expert validation. The implementation stage involved 38 fifth-grade students at Khadijah Bagik Nyaka Islamic Elementary School, East Lombok, West Nusa Tenggara. The evaluation stage assessed the module's validity, practicality, and effectiveness. The module obtained an average validity score of 90.25% and was categorized as highly valid. The practicality assessment reached 90.49%, indicating that the module was highly practical. The mean pretest score increased from 51.55 to 78.29 on the posttest, yielding an N-Gain score of 0.56, which falls in the moderate category. These findings indicate that the module successfully integrates plane geometry concepts with Sasak weaving motifs, thereby facilitating more concrete, contextual, and meaningful mathematics learning.

Keywords: plane geometry module, ethno–collaborative inquiry, ethnomathematics, deep learning, elementary school.

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INTRODUCTION

Mathematics instruction at the elementary school level, particularly regarding plane figures, presents a variety of complex challenges (Li, 2025). Recent studies indicate that elementary school students often struggle to understand concepts in plane geometry (Cotiè et al., 2024). These difficulties are primarily caused by a teaching approach that remains procedural, in which teachers place greater emphasis on memorizing formulas and mechanical steps than on conceptual understanding (Chotimah et al., 2020). This results in students' limited ability to connect concrete, visual, and symbolic representations and their failure to transfer concepts to new situations.

The urgency of this issue is underscored by a preliminary study conducted at two elementary schools in Mataram City in 2025, which showed that 34.6% of fifth-grade students were unable to calculate the perimeter and area of two-dimensional shapes, 41.2% had difficulty constructing simple three-dimensional shapes, and 26.7% of students had low critical thinking skills (Suteja & Setiawan, 2022). These findings underscore the need for geometry instruction that is not merely procedural but also integrates cultural contexts to support critical thinking skills and deepen students' understanding of mathematical concepts (Falebita et al.., 2025; Lepheana & Sibanda, 2025).

The deep learning curriculum is oriented toward student-centered, contextual learning and emphasizes the development of the Pancasila Student Profile (Meij & Merx, 2018). One dimension of the graduate profile in the deep learning curriculum is critical thinking, which is currently not widely fostered in elementary school mathematics instruction (Nsengimana et al., 2025). One potential approach to optimizing critical thinking is to integrate local cultural contexts into mathematics instruction through ethnomathematics. Cultural contexts provide a tangible starting point for students to construct mathematical concepts, as they are rooted in their daily experiences and environments (Hastuti et al., 2025). This integration can increase student engagement and facilitate a deeper understanding of geometry (Balasa & Tukur, 2021).

Particularly in Lombok, West Nusa Tenggara, the Sasak people's culture is rich in geometric elements, such as traditional weaving motifs, ornaments on traditional houses, and floor patterns used in traditional ceremonies (Sutarto et al., 2021; Hastuti et al., 2024). These structures explicitly represent two-dimensional shapes such as triangles, rectangles, circles, and parallelograms. However, this potential for ethnomathematics has not yet been systematically integrated into elementary school mathematics instruction. Research indicates that using local cultural contexts can enhance students' motivation and problem-solving skills (Sutarto et al., 2022). However, this integration will not be successful without the support of a learning model that facilitates exploration, discussion, and reflection. One learning model that facilitates these activities is collaborative inquiry. This model combines inquiry-based and cooperative learning approaches, both of which have been shown to enhance critical thinking skills (Hastuti et al., 2020). The stages of the Collaborative-Based Inquiry learning model are: 1) orientation, 2) problem, 3) prediction, 4) exploration, 5) analysis, 6) evaluation, and 7) monitoring. When students collaborate, they can exchange ideas by asking questions, providing explanations, and negotiating. In a collaborative inquiry learning environment, students will be able to make joint decisions about how to solve problems.

Research on the development of elementary school mathematics learning materials has shown rapid progress over the past decade. Various studies have produced valid and practical modules based on local culture, such as two-dimensional ethnomathematics modules, e-modules based on Balinese culture, and the use of cultural artifacts as teaching media for geometry (Triwahyuningtyas et al., 2020; Madu et al., 2025; Karimah et al., 2025). The Collaborative Inquiry model is increasingly being applied in elementary school mathematics instruction because it effectively promotes active, reflective, and collaborative learning. Several studies indicate that this model can enhance students' critical thinking skills, conceptual understanding, and metacognition (Dewita et al., 2025; Afikah et al., 2025).

Nevertheless, there remain gaps in the research, particularly regarding systematic studies that explicitly integrate local cultural contexts into every stage of inquiry in elementary school geometry instruction, as well as a lack of long-term evaluations of the impact on students' mathematical understanding and cultural appreciation (Darmuki et al., 2023; Dewita et al., 2025). Within the deep learning framework, key indicators include conceptual understanding, problem-solving, critical thinking, and knowledge transfer, which are measured through formative assessments, reflection, and collaborative observation (Syata et al., 2023; Zang & Wang, 2025). Culturally based contextual learning has been shown to strengthen reflection and critical thinking through guided reflection strategies, peer feedback, and inquiry scaffolding (Rahardjo et al., 2025; Nurhayani et al., 2025).

Based on this gap, this study offers an integrated approach by developing a plane figures module grounded in Ethno Collaborative Inquiry, which systematically integrates local ethnomathematics into every stage of inquiry-based learning (Khan & Ahmed, 2025). This approach is designed not only to help students understand the concepts of plane figures procedurally but also to build a more meaningful conceptual understanding by connecting mathematics to cultural contexts close to their lives (Nunaki et al., 2019; Aidoo et al., 2022). The integration of local ethnomathematics elements is expected to foster contextual, collaborative, and reflective learning, enabling students to explore geometric concepts through activities such as asking questions, observing, discussing, identifying patterns, and drawing conclusions together. This module is intended to support deep learning in mathematics at the elementary school level, strengthen students' critical and collaborative thinking skills, and serve as an alternative teaching resource relevant to 21st-century learning needs and the preservation of local cultural values.

This study aims to develop an Ethno–Collaborative Inquiry-based Flat Shapes Module that is valid, practical, and effective in supporting deep learning among primary school pupils. The module was developed by integrating concepts of plane figures and the context of local ethnomathematics into the stages of collaborative inquiry-based learning, so that the learning process is not only oriented towards mastering formulas and problem-solving procedures, but also towards the formation of conceptual understanding, the ability to relate mathematical concepts to everyday situations, and the strengthening of critical thinking, communication, and collaboration skills. Specifically, this study seeks to address three main issues: the characteristics of the module developed to support deep learning; the module's validity and practicality in primary school mathematics education; and the module's effectiveness in enhancing pupils' understanding of plane figure concepts. The results of this study are expected to provide an alternative teaching resource that is contextual, meaningful, and aligned with the needs of primary school mathematics education.

METHOD

Research Design

This study employed a research and development (R&D) methodology using the ADDIE model, which comprises five stages: Analysis, Design, Development, Implementation, and Evaluation. The ADDIE model was selected for its systematic, structured, and relevant nature in developing a learning product in the form of an Ethno–Collaborative Inquiry-Based Plane Figures Module. This module was developed to support deep learning among elementary school students. This study was conducted with fifth-grade students at SD Islam Khadijah Bagik Nyaka in East Lombok, West Nusa Tenggara, with a total of 38 research subjects.

Instruments

The research instruments included an expert validation form, teacher and student response questionnaires, an observation sheet for the implementation of learning, and pre- and post-tests. The expert validation form was used to evaluate the module's quality across content suitability, language, presentation, design, and alignment with the characteristics of the Ethno–Collaborative Inquiry approach. The validation data were analyzed by calculating percentage scores for each aspect and the overall average score, which served as the basis for determining the module's validity category. Meanwhile, the teacher and student response questionnaires were used to gather information on the module's practicality, including ease of use, readability, appeal, usefulness, and suitability for teaching implementation. The questionnaire data were processed as percentages and then interpreted based on predetermined practicality criteria. The observation sheets were used to assess the implementation of each stage of the learning process, whilst the pre-test and post-test results were utilized to measure the module's effectiveness in enhancing pupils' understanding of plane-figure concepts.

Before being administered as the pre-test and post-test, the achievement test underwent validity and reliability testing. Content validity was assessed by three validators with expertise in elementary mathematics education, educational evaluation, and instrument development. The assessment covered the alignment of the test items with the learning objectives, the representation of indicators of understanding in plane geometry, the accuracy of the mathematical content and item construction, and the clarity of the language used. The validators' assessments were analyzed using Aiken's V, with an item considered valid if it had a coefficient of 0.80 or higher. Empirical validity was subsequently examined using the corrected item–total correlation, with a minimum acceptance criterion of 0.30. The instrument's reliability was assessed using Cronbach's alpha to determine the internal consistency of the test items. The instrument was considered reliable when the coefficient was at least 0.70. Only items that met the validity and reliability criteria were used in the administration of the pretest and posttest.

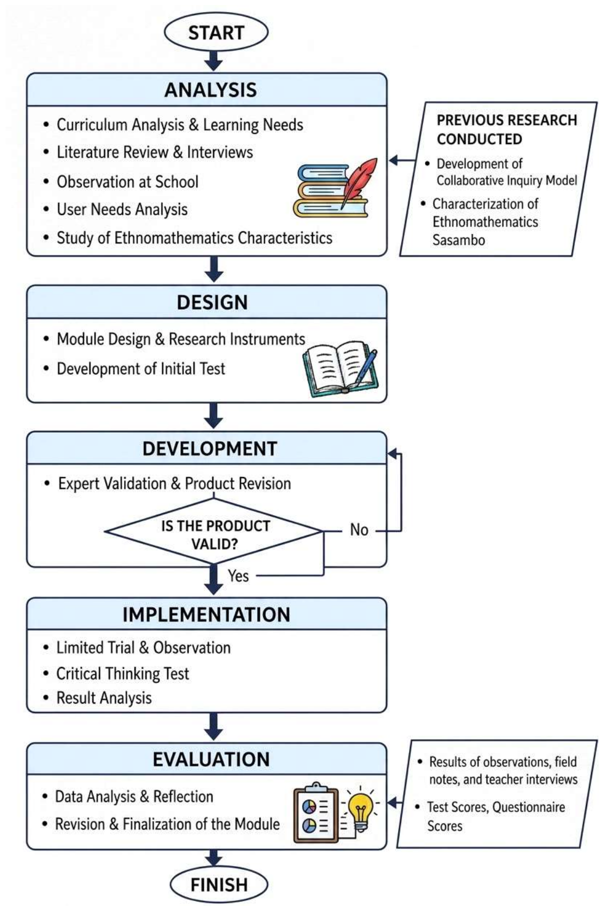

Figure 1. Research flowchart

Research Procedures

This study employed the ADDIE development model, which consists of five main stages: Analysis, Design, Development, Implementation, and Evaluation. These five stages were systematically applied to produce an Ethno–Collaborative Inquiry-Based Plane Figures Module that is appropriate, practical, and effective in supporting deep learning among elementary school students.

Analysis

The Analysis phase is the initial stage aimed at identifying learning needs, issues occurring in schools, and the characteristics of students and learning materials. During this phase, an analysis of the curriculum and learning needs was conducted to ensure that the geometry materials align with the learning outcomes. Additionally, a literature review, interviews with teachers, classroom observations, a user needs analysis, and a study of local ethnomathematics characteristics were conducted. This phase is also supported by previous research, including the development of the Collaborative Inquiry model and the characterization of Sasambo ethnomathematics, which serve as the foundation for designing contextual and meaningful learning modules.

Design

The Design phase focuses on developing the initial product design and research instruments. In this phase, the researcher designed the Ethno–Collaborative Inquiry-Based Plane Figures Module, taking into account the results of the needs analysis, student characteristics, learning outcomes, and the principles of deep learning. The module design included the learning structure, learning objectives, collaborative inquiry activities, instructional materials, exercises, reflection activities, and learning assessments. Additionally, various research instruments were developed during this stage, including expert validation forms, teacher and student response questionnaires, observation sheets for monitoring lesson implementation, and assessment instruments such as pretests and posttests.

Development

The Development stage involved producing the initial module based on the design formulated in the previous stage. The module contained plane geometry materials integrated with Sasak weaving motifs, Ethno–Collaborative Inquiry activities, worksheets, exercises, reflection activities, and learning assessments. The initial product was validated by three experts: an elementary mathematics content expert, an instructional media or teaching-material development expert, and a language or elementary education expert. The content expert evaluated the accuracy of geometric concepts and their alignment with the learning outcomes. The media expert assessed the organization, readability, visual design, and presentation of the module. In contrast, the language expert evaluated the clarity, comprehensibility, and appropriateness of the language for fifth-grade students. The expert feedback was used to revise and refine the module before classroom implementation. The test items that met the validity and reliability criteria were subsequently used during the implementation stage to measure students' understanding of plane geometry.

Implementation

The Implementation Phase is the stage in which the module is applied in classroom learning activities. In this phase, the Ethno–Collaborative Inquiry-Based Plane Figures Module was pilot tested on a small scale with fifth-grade elementary school students. The implementation process included learning activities using the module, observations of the learning process, the administration of pretests and posttests, and the collection of response data from teachers and students. This stage aims to provide an overview of the module's practicality in the learning process and to determine the impact of its use on students' understanding of plane figures.

Evaluation

The evaluation stage assessed the quality of the developed module in terms of validity, practicality, and effectiveness. Data on module validity were obtained from expert validation forms, whereas practicality data were collected through teacher and student response questionnaires and learning implementation observation sheets. All assessment instruments employed a five-point Likert scale ranging from 1 to 5, where 1 indicated the lowest level of agreement or appropriateness and 5 the highest. The scores obtained from each instrument were summed and converted into percentages using the formula P = (So/Sm) × 100%, where P represents the percentage of validity or practicality, S_o represents the total empirical score obtained, and S_m represents the maximum possible score. The maximum score was determined by multiplying the number of assessment items, the highest score on the rating scale, and the number of validators or respondents. The percentage for each aspect or source of assessment was calculated separately, whereas the overall validity and practicality scores were obtained by averaging the resulting percentages.

Data Analysis

Module validity was determined from expert assessments covering content feasibility, language, presentation, module design, and alignment with the Ethno–Collaborative Inquiry approach. A percentage of 85.01%–100% was classified as highly valid, 70.01%–85% as valid, 50.01%–70% as moderately valid, and 50% or below as less valid. Module practicality was determined based on teacher and student responses and observations of learning implementation. A percentage of 85.01%–100% was classified as highly practical, 70.01%–85% as practical, 50.01%–70% as moderately practical, and 50% or below as less practical. The module was considered suitable for classroom implementation when it achieved at least the valid and practical categories.

Module effectiveness was analyzed by comparing students' pretest and posttest scores. Descriptive analysis included the mean score, gain score, and N-Gain. Prior to inferential analysis, the normality of the difference scores was examined using the Shapiro–Wilk test. A significance value greater than 0.05 indicated that the difference scores were normally distributed. A paired-samples *t*-test was subsequently conducted to determine whether the difference between the pretest and posttest scores was statistically significant. At the same time, Cohen's d_z was calculated to determine the magnitude of the effect. The N-Gain score was calculated using the formula $g = (S_{post} - S_{pre}) / (S_{max} - S_{pre})$. N-Gain values were classified as high when $g > 0.70$, moderate when $0.30 < g < 0.70$, and low when $g < 0.30$. The module was considered effective when the mean N-Gain reached at least the moderate category and the paired-samples *t*-test indicated a statistically significant difference between the pretest and posttest scores.

RESULT AND DISCUSSION

The research results are presented systematically, following the stages of the ADDIE development model: Analysis, Design, Development, Implementation, and Evaluation. Each stage makes a significant contribution to the development process of the Ethno–Collaborative Inquiry-Based Plane Figures Module, ranging from the identification of learning needs, the design of the module's structure and content, the development of the initial product, the implementation of pilot testing in the classroom, to the evaluation of the quality of the final product. The presentation of the results includes data on the analysis of teacher and student needs, the module design developed based on the local ethnomathematics context, the results of the product's development and refinement, the implementation of the module over three learning sessions, as well as an assessment of the module's suitability, practicality, and effectiveness in supporting deep learning among elementary school students.

Analysis Stage

The Analysis phase was conducted as an initial step to gain a comprehensive overview of learning needs, the challenges faced by teachers and pupils, and opportunities to utilize local ethnomathematics in teaching plane figures. Based on a review of the curriculum, the plane figures syllabus for Year 5 of primary school requires pupils to determine the perimeter and area of various plane figures, such as triangles, quadrilaterals, polygons, and composite figures. Mastery of this material requires more than simply memorizing formulae; it necessitates conceptual understanding so that pupils can identify shapes, compare sizes, calculate areas and perimeters, and apply these concepts in real-life situations.

Preliminary observations indicate that the teaching of plane figures is still largely carried out using a procedural approach. Pupils tend to be guided to memorize formulas and solve problems mechanically, and consequently experience difficulties when asked to relate geometric concepts to objects or phenomena in their immediate environment. This situation highlights the need to develop teaching materials that provide a concrete, visual, contextual, and collaborative learning experience. In this context, Sasak weaving motifs were selected as a source of ethnomathematics because they contain various elements of plane geometry, such as squares, rectangles, triangles, repeating patterns, and symmetry, which are relevant to primary school mathematics education.

Table 1. Results of learning needs analysis

Aspect Analyzed	Main Findings	Implications for Module Development
Curriculum	The plane geometry topic requires students to understand the perimeter and area of various plane figures, including composite shapes.	The module should present learning activities that progress from identifying basic plane figures to calculating their perimeters and areas, and subsequently applying these concepts to composite figures.
Learning problems	Students tend to memorize formulas and have difficulty relating geometric concepts to real objects in their surroundings.	The module should include activities that require students to identify geometric shapes in photographs of authentic Sasak woven motifs, compare their properties, and connect these observations with mathematical concepts.
Teacher needs	Teachers require instructional materials that provide clear guidance for implementing inquiry-based and collaborative	The module should provide structured learning procedures, guiding questions, group-work instructions, teacher facilitation

	learning.	notes, and assessment rubrics aligned with the stages of Collaborative Inquiry.
Student needs	Students need learning resources that are visual, concrete, engaging, and culturally familiar.	The module should use clear visual representations of Sasak woven motifs, contextual problems, worksheets, and hands-on project activities that are appropriate for fifth-grade students.
Ethnomathematics potential	Sasak woven motifs contain plane figures, repeated patterns, symmetry, and combinations of geometric shapes.	Sasak woven motifs should be used as the main learning context for identifying plane figures, analyzing patterns and symmetry, calculating perimeter and area, and designing students' own mathematical weaving motifs.

Table 1 indicates that the module's development should be directed toward contextual, visual, and collaborative learning. The findings indicate that students require more than formula-based explanations and routine exercises; they need learning activities that connect geometric concepts with concrete objects from their cultural environment. Therefore, the module was designed to incorporate authentic Sasak woven motifs as the primary ethnomathematical context. These motifs were used in activities involving the identification of plane figures, the analysis of repeated patterns and symmetry, the calculation of perimeter and area, group discussion, and the creation of mathematical weaving-motif projects. In addition, the module provides structured inquiry procedures, guiding questions, collaborative worksheets, and assessment rubrics to help teachers systematically implement each stage of Collaborative Inquiry.

Design Stage

The Design phase was carried out to develop a preliminary draft of the Ethno–Collaborative Inquiry-Based Plane Geometry Module. The module design was based on the results of a needs analysis, learning outcomes, the characteristics of fifth-grade students, and the potential for local ethnomathematics found in Sasak weaving motifs. This module is designed so that learning about plane figures occurs systematically and in context, starting with an introduction to local culture, the identification of geometric elements in weaving motifs, the calculation of area and perimeter, and culminating in a mathematical weaving-motif project.

The module structure includes the learning identity, learning outcomes, graduate profile dimensions, facilities and infrastructure, target students, learning model, topics, learning objectives, partnerships, learning environment, use of digital tools, activity steps, worksheets, and assessment rubrics. The learning activities are organized into three interconnected sessions. The first session introduces Sasak weaving motifs as mathematical patterns; the second calculates their perimeter and area; and the third creates a project featuring Sasak weaving motifs as an application of plane geometry concepts.

Table 2 shows that the initial design of the Ethno–Collaborative Inquiry-Based Plane Figures Module was developed by using Sasak weaving motifs as the primary context for mathematics learning. The developed material covers plane figures, area, perimeter, and composite figures linked to geometric elements

Table 2. Initial design of the ethno–collaborative inquiry geometry module

Module Component	Module Component
Learning topic	Sasak woven motifs as mathematical patterns
Main material	Plane geometry, area, perimeter, and combined plane figures
Learning context	Sasak woven motifs containing squares, rectangles, triangles, repeated patterns, and symmetry
Learning model	Collaborative Inquiry
Learning syntax	*Orientation, Problem, Prediction, Exploration, Analysis, Evaluation,* and *Monitoring*
Learning activities	Observation of woven motifs, group discussion, hypothesis formulation, exploration of area and perimeter, project creation, presentation, and reflection
Assessment	Formative assessment, project assessment, collaboration assessment, and reflection

in the weaving motifs, such as squares, rectangles, triangles, repeating patterns, and symmetry. This module uses the Collaborative Inquiry model, with the stages: Orientation, Problem, Prediction, Exploration, Analysis, Evaluation, and Monitoring. Learning activities are designed through observation of motifs, group discussions, hypothesis formulation, exploration of area and perimeter, project creation, presentations, and reflection. Assessment in the module includes formative assessment, project assessment, collaboration, and student reflection.

Development Stage

The Development phase involved developing modules based on the design created during the Design phase. The initial product produced includes material on plane figures integrated with the context of Sasak weaving motifs, collaborative inquiry activities, worksheets, prompt questions, group assignments, project activities, and assessment rubrics. The development of these modules aims to facilitate students' understanding of plane figure concepts through concrete, contextual, and meaningful learning experiences.

In the initial design, the learning activities were organized into three interconnected sessions. The first session focused on observing Sasak weaving patterns, identifying geometric shapes, and calculating area using unit squares. The second session was dedicated to calculating the area and perimeter of the patterns, comparing the results, and evaluating the effectiveness of using formulas to solve problems. Meanwhile, the third session consisted of a project activity in which students created mathematical weaving patterns that included at least two rectangles, two triangles, and a repeating pattern.

Preliminary results indicate that the module excels in contextual relevance by using local Sasak culture as a resource for learning mathematics. In addition, the module stands out for its learning activities, which guide students to actively observe, discuss, explore, analyze, present, and reflect on their learning outcomes. Several components of the module still require refinement, particularly regarding the completeness of the module's identity, the clarity of time allocation, the consistency of terminology, and the alignment of the assessment rubric with the focus of mathematics learning. Rubrics that still contain less relevant aspects need to be adjusted to align with the learning indicators for plane figures, ethnomathematics, collaboration, and student metacognition. This is evident in Table 3.

Table 3. Product revision based on module review

Reviewed Aspect	Initial Findings	Revision Actions
Module identity	Some parts, such as school name and time allocation, were not fully completed.	Complete all identity components and time allocation.
Learning objectives	Objectives were still general.	Add specific indicators related to identifying shapes, calculating area and perimeter, and designing motifs.
Learning activities	The inquiry syntax had been included.	Clarify the relationship between each syntax and ethnomathematics activities.
Assessment rubric	Some aspects of the rubric were not fully aligned with mathematics learning.	Revise the rubric to focus on geometry, collaboration, creativity, communication, and reflection.
Visual presentation	The module still needed stronger visual support.	Add clearer images of Sasak woven motifs and student worksheets.

Table 3 shows that the initial module draft already had a learning structure consistent with the Ethno–Collaborative Inquiry approach, but still required some refinements. Revisions were primarily made to ensure the completeness of the module's identity, clarify the relationship between inquiry syntax and ethnomathematics activities, clarify the learning objectives, adjust the assessment rubric, and enhance the visual presentation. These improvements aim to make the developed module more systematic, contextual, and aligned with the learning needs for plane figures in elementary school.

Module Validity

The validation of the Ethno–Collaborative Inquiry-Based Plane Figures Module involved three validators with expertise in elementary mathematics education, instructional media and teaching material development, and language. The assessment was conducted using a five-point Likert-scale validation form, with 1 as the lowest and 5 as the highest score. The evaluated aspects included content feasibility, language, presentation, module design, and alignment with the characteristics of the Ethno–Collaborative Inquiry approach. The scores assigned by all validators for each aspect were summed and subsequently converted into percentages using the formula $P = (S_o/Sm) \times 100\%$, where S_o represents the obtained score and S_m represents the maximum possible score. The percentage obtained for each aspect was then used to determine its validity category, and the module's overall validity was calculated by averaging the percentages across all assessment aspects. The results of the module validity analysis are presented in Table 4.

Table 4 shows that the content suitability aspect scored 90.00 percent, the linguistic aspect 87.50 percent, the presentation aspect 91.67

Table 4. Results of module validation

Assessment Aspect	Percentage	Category
Content feasibility	90.00%	Highly valid
Language	87.50%	Highly valid
Presentation	91.67%	Highly valid
Module design	89.58%	Highly valid
Alignment with Ethno–Collaborative Inquiry	92.50%	Highly valid
Overall average	90.25%	Highly valid

percent, the module design aspect 89.58 percent, and the aspect of alignment with the Ethno–Collaborative Inquiry approach 92.50 percent. Overall, the module's average validity score was 90.25 percent, placing it in the 'highly valid' category. The highest percentage was recorded for the module's alignment with the Ethno–Collaborative Inquiry approach, whilst the lowest was for the linguistic aspect. Nevertheless, all assessment aspects met the criteria for 'highly valid'. The validators also provided several recommendations for improvement, including standardizing terminology, simplifying activity instructions, adding illustrations of Sasak weaving motifs, and aligning the assessment rubric with the learning objectives. Once all these recommendations had been implemented, the module was deemed suitable for use in the learning implementation phase.

Implementation Stage

The implementation phase was conducted to assess the feasibility of the Ethno–Collaborative Inquiry-Based Plane Geometry Module in the mathematics learning process for fifth-grade elementary school students. The implementation took place over three sessions, each with a different focus but interconnected. The first session introduced Sasak weaving motifs as mathematical patterns; the second focused on calculating the perimeter and area of plane figures; and the third was dedicated to a project creating mathematical weaving motifs based on plane figures. All learning activities followed the Collaborative Inquiry syntax, namely orientation, problem, prediction, exploration, analysis, evaluation, and monitoring.

In the first session, the lesson introduced Sasak weaving motifs as an initial context for understanding two-dimensional shapes. Through documentation of the group's work, it was evident that students observed weaving patterns composed of color combinations and repeating shapes. During the orientation phase, students were guided to examine these motifs closely and identify the elements of two-dimensional shapes present within them. The students' work demonstrated that they could recognize several geometric shapes, particularly squares and rectangles, and identify other characteristics present in the motif patterns. Afterward, during the problem and prediction stage, students were presented with a problem about determining the size of a motif without measuring tools. In this activity, students began to express initial hypotheses about how to determine the area of a motif, either by counting unit squares or by estimating the number of parts in the pattern. This can be seen in Figure 2.

Figure 2 shows the students' worksheets from the first session, during which they identified Sasak weaving motifs as two-dimensional shapes. The students' work demonstrates that they recognized geometric elements in the weaving motifs, particularly squares and rectangles. This activity demonstrates that Sasak weaving motifs can serve as a concrete, contextual medium for introducing the concept of two-dimensional shapes to elementary school students. In this activity, students were not immediately directed to use formulas; instead, they were first encouraged to observe visual patterns, discuss the shapes they found, and connect them to mathematical concepts. Thus, the first session served as a crucial foundation for building students' conceptual understanding through collaborative, locally-based learning.

In the second session, the learning activities focused on reinforcing the concepts of perimeter and area. Students were presented with a contextual problem about a weaver who wanted to sell woven fabric and needed to quickly calculate the fabric's dimensions. Students were then asked to assess whether counting squares one by one was still an effective method. The

Figure 2. Students' worksheet in the first meeting: identifying sasak woven motifs as plane geometry patterns

students' responses indicated that they understood this method was inefficient because it took too long. Next, the students began to connect calculation strategies to length and width measurements. In one of the group assignments, students calculated the perimeter of a rectangular piece of fabric measuring 6 units by 4 units, resulting in a perimeter of 20 cm and an area of 24 cm². This is shown in Figure 3.

Figure 3 illustrates the learning activities during the second session of the exploration and analysis stages within the Ethno–Collaborative Inquiry framework. During the exploration stage, students were guided to examine the dimensions of weaving motifs by identifying the length, width, perimeter, and area of the two-dimensional shapes within the motif patterns. Subsequently, during the analysis stage, students compared calculation strategies using unit squares with those using mathematical formulas. Through this process, students not only obtained calculation results but also understood that formulas are used to solve problems more efficiently and in a structured, systematic manner. The developed module supports deep learning by guiding students to connect mathematical concepts, problem-solving procedures, and their applications within cultural and real-life contexts.

In the third session, the learning activity focused on creating a mathematical weaving pattern project to apply the concept of two-dimensional shapes. Based on the documentation

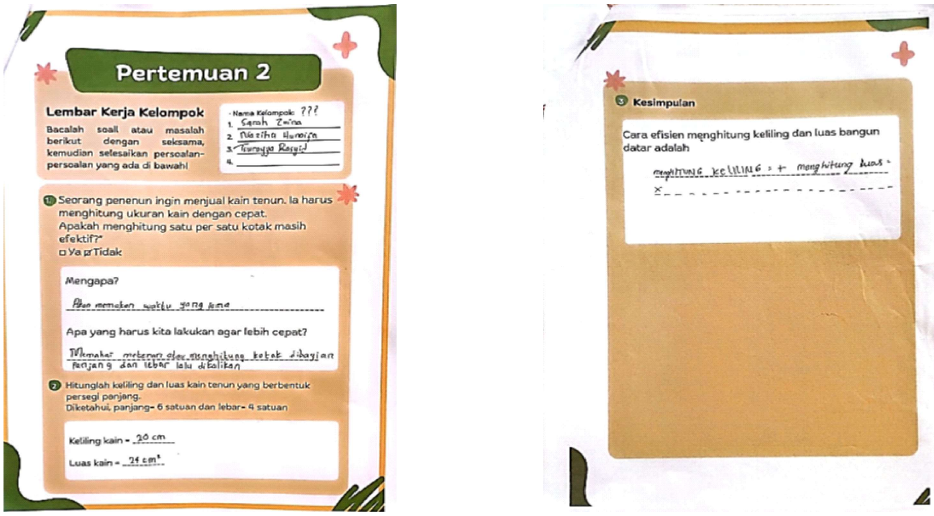

Figure 3. Students' worksheet in the second meeting: calculating perimeter and area of woven motifs

obtained, students were asked to design a pattern on graph paper that included at least two rectangles, two triangles, a repeating pattern, elements of symmetry, and color. The students' work demonstrated that they could create pattern designs using various geometric shapes, such as squares, rectangles, and triangles. In addition to producing visual works, the students filled out an identification table listing the types of plane figures, the number of elements, the perimeters, and the areas of the geometric elements used in the patterns. One group, for example, recorded the number of two-dimensional shapes in their motif design and then attempted to calculate their perimeters and areas. This activity demonstrates a process of knowledge transfer, as students were able apply the concepts of two-dimensional shapes they had learned to create works rooted in local culture in a creative, contextual, and meaningful way. This can be seen in Figure 4.

Figure 4. Students' project in the third meeting: creating mathematical sasak woven motifs using plane figures

Figure 4 shows that the third session represents the evaluation and monitoring stages. During the evaluation stage, students applied concepts of two-dimensional shapes through a weaving-pattern project. In contrast, during the monitoring stage, students reflected on the learning process through their work and the conclusions they drew. The mathematical weaving pattern project demonstrated that students not only understood the concepts procedurally but also applied them creatively within a cultural context. This activity reinforces students' collaboration, creativity, communication, and conceptual understanding. Documentation of the implementation shows that the developed module can be used practically in learning and has the potential to support deep learning through contextual, collaborative, exploratory, and reflective activities.

Module Practicality

The practicality of the Ethno–Collaborative Inquiry-Based Plane Figures Module was analyzed using data from the teacher response questionnaire, 38 students' response questionnaires, and the learning implementation observation sheet. All three instruments employed a five-point Likert scale ranging from 1 to 5. The scores obtained from each instrument were summed and converted into percentages by comparing the empirical score with the maximum possible score using the formula $P = (S_o/S_m) \times 100\%$. The percentages for teacher responses, student responses, and learning implementation were calculated separately and subsequently interpreted according to the predetermined practicality criteria. The module's overall practicality was determined by calculating the mean percentage across the three assessment sources. A summary of the module practicality analysis is presented in Table 5.

Table 5 shows that the results for teacher responses were 92.50 percent, for student responses 88.68 percent, and for the implementation of learning 90.28 percent. All three results fall within the 'highly practical' category. Overall, the module's average practicality rating was 90.49 percent, indicating it is categorized as highly practical. These findings indicate that the module has clear instructions for use, is easy for both teachers and pupils, presents the material engagingly, and facilitates the systematic implementation of each stage of Ethno–Collaborative Inquiry. The use of Sasak weaving motifs as an ethnomathematics context also helps pupils relate the concept of plane figures to cultural artifacts familiar in their everyday lives. The module developed meets the practical criteria for implementation in school mathematics teaching.

Table 5. Results of module practicality

Source of Assessment	Percentage	Category
Teacher response	92.50%	Highly practical
Student response	88.68%	Highly practical
Learning implementation	90.28%	Highly practical
Overall average	90.49%	Highly practical

Validity of Test Instruments

Validity tests were carried out to ensure that the pre-test and post-test instruments were adequately aligned with the learning objectives and the indicators of conceptual understanding of plane figures to be measured. The initial instrument comprised 10 items designed to measure pupils' ability to identify the shapes and properties of plane figures, calculate perimeters and areas, solve contextual problems, and apply geometric concepts to Sasak weaving patterns. The results of the instrument's validity testing are shown in Table 6.

Table 6. Results of the test instrument validity test

Analysis Component	Result	Acceptance Criterion	Decision
Initial number of items	10 items	–	–
Range of Aiken's V coefficients	0.83–1.00	≥ 0.80	Valid
Mean Aiken's V coefficient	0.92	≥ 0.80	Valid
Range of corrected item–total correlations	0.42–0.78	≥ 0.30	Acceptable
Valid items	10 items	≥ 0.30	Retained
Revised or eliminated items	0 items	< 0.30	None
Final number of items	10 items	–	Suitable for use

Table 6 shows that the Aiken's V coefficients for all items range from 0.83 to 1.00, with an average value of 0.92. All these values have exceeded the minimum threshold for content validity of 0.80; it can therefore be concluded that each item is adequately aligned with the learning objectives, the indicators of understanding of plane figure concepts, the scope of the material, the construction of the questions, and the linguistic characteristics of Year 5 primary school pupils. Furthermore, the results of the empirical validity testing showed that the corrected item-total correlation coefficients ranged from 0.42 to 0.78. As all items obtained coefficients above 0.30, all 10 items were deemed to meet the criteria for empirical validity and were retained for use in the pre-test and post-test. These findings indicate that each item has a strong relationship with the instrument's total score and can consistently measure pupils' understanding of plane figure concepts. The fulfillment of content validity and empirical validity provides a strong basis for the use of the instrument in measuring the effectiveness of the module, so that changes in pre-test and post-test scores can be interpreted as changes in students' understanding, rather than as a result of the items being inaccurate in relation to the indicators being measured.

Reliability of Test Instruments

Once all items in the instrument met the criteria for content and empirical validity, the next stage was to conduct a reliability test to assess the instrument's internal consistency in measuring pupils' understanding of plane figure concepts. This test was essential to ensure that each item in the instrument was sufficiently interrelated and consistently measured the same construct. A reliability analysis was carried out on the 10 items that had been declared valid, using Cronbach's alpha. The instrument was deemed to have adequate reliability if the coefficient obtained was at least 0.70. The higher the reliability coefficient, the stronger the instrument's consistency in producing stable and reliable measurements. The results of the test instrument's reliability test are shown in Table 7.

Table 7 shows that the reliability test yielded a Cronbach's alpha coefficient of 0.86. This value exceeds the minimum reliability threshold of 0.70;

Table 7. Results of the test instrument reliability test

Analysis Component	Result	Acceptance Criterion	Interpretation
Number of items tested	10 items	–	–
Cronbach's alpha coefficient	0.86	≥ 0.70	Reliable
Reliability category	High	–	Highly reliable

consequently, the instrument can be categorized as having a high level of reliability. This finding indicates that all test items have adequate internal consistency and are relatively stable in measuring pupils' understanding of plane-figure concepts. The high reliability coefficient also indicates a strong correlation among items within the instrument, meaning that the measurement results are trustworthy and can be used reliably in both pre-tests and post-tests. Having met the criteria for validity and reliability, the instrument provides a robust basis for measuring the effectiveness of the Ethno–Collaborative Inquiry-Based Plane Figures Module, as changes in pupils' scores are measured with adequate accuracy and internal consistency.

Evaluation Stage

The evaluation phase assessed the extent to which the Ethno–Collaborative Inquiry-based Plane Figures Module effectively supports deep learning among primary school pupils. The module's effectiveness was analyzed using pre- and post-test results from 38 pupils. The analysis was carried out descriptively by calculating means and N-Gain, and inferentially using a paired t-test to determine the significance of the improvement in learning outcomes. The results are shown in Table 8.

Table 8. Summary of students' pretest and posttest results

Assessment Component	Score
Number of students	38
Mean pretest score	51.55
Mean posttest score	78.29
Mean gain score	26.74
Mean N-Gain score	0.56
N-Gain category	Medium
Highest pretest score	62

Table 8 shows the results of the learning evaluation based on pretest and posttest data for 38 fifth-grade students. According to the analysis, the students' average pretest score was 51.55, while their average posttest score increased to 78.29. This increase resulted in an average gain of 26.74, indicating a positive change in students' learning outcomes after participating in instruction using the Ethno–Collaborative Inquiry-Based Plane Figures Module. Additionally, the average N-Gain score of 0.56 falls within the moderate category, suggesting that the module was reasonably effective in improving students' understanding of plane figures. The highest score on the pretest was 62, indicating that, before instruction, students' initial achievement was at a moderate level and that there was still room for improvement after receiving instruction using the module.

Table 9. Results of the paired-samples t-test

Comparison	Mean Difference	*t*	*df*	*p*-value	Cohen's *dz*
Pretest–Posttest	26.74	24.01	37	< .001	3.90

Table 9 shows a statistically significant difference between the pretest and posttest scores, $t(37) = 24.01$, $p < .001$. The effect size measured using Cohen's dz was 3.90, indicating a very large effect. These findings suggest that students' understanding of plane geometry improved significantly after learning with the Ethno–Collaborative Inquiry-Based Plane Figures Module.

Figure 5 shows a paired boxplot comparing the distributions of students' pre-test and post-test scores. The horizontal line in the center of the box represents the median, whilst the lower and upper boundaries of the box indicate the first and third quartiles, respectively. The triangle symbol denotes the mean, whilst points lying outside the range of the whiskers indicate outliers. The distribution of pre-test scores tends to be

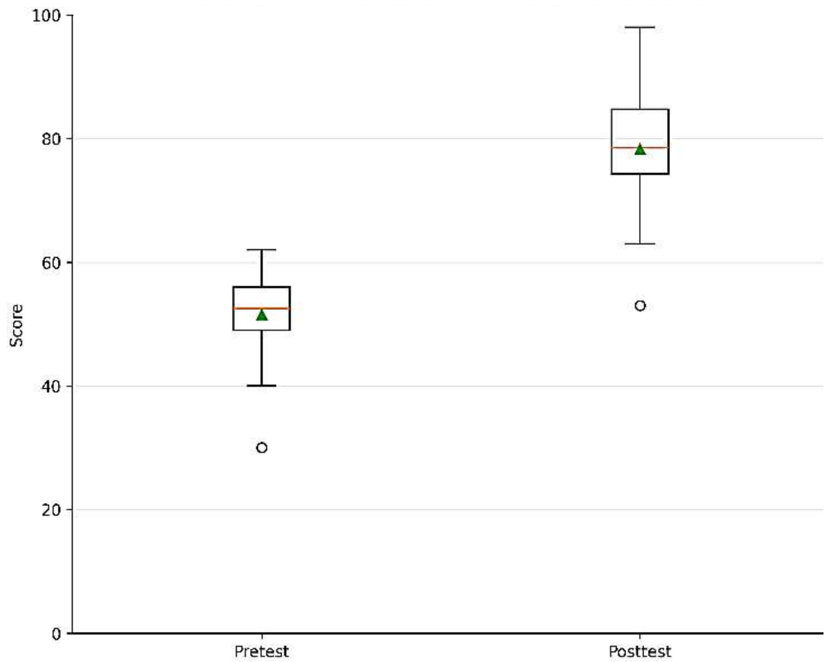

Figure 5. Paired boxplot of students' pretest and posttest scores

lower, with a median of around 53 and most scores concentrated in the range 49–56. Conversely, the distribution of post-test scores has shifted upward, with a median of around 78 and most scores falling between 74 and 85. Although there is one outlier in each group, the overall distribution of post-test scores still shows a higher mean than the pre-test scores. These visual findings indicate that the improvement in learning outcomes is reflected not only in the rise in the mean score but is also evident in the increase in the median and the shift in the interquartile range. The implementation of the Ethno–Collaborative Inquiry-based Plane Figures Module is associated with improved pupils' overall learning achievement.

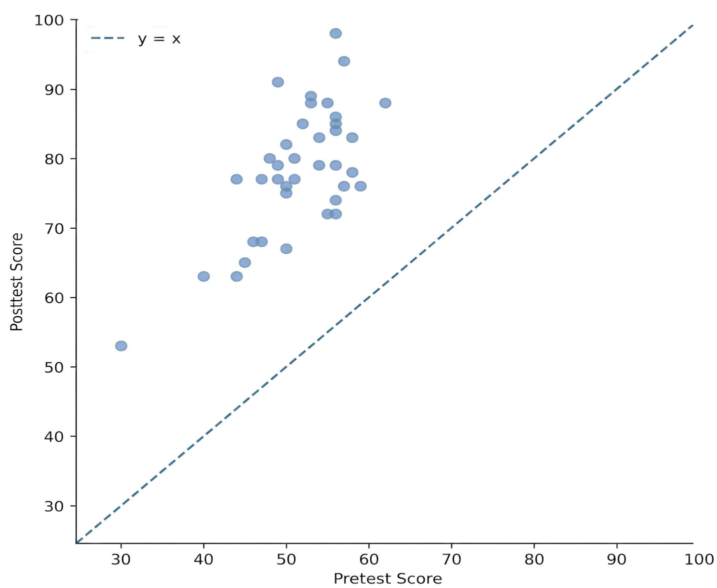

Figure 6. Scatter plot of students' pretest and posttest scores

Figure 6 shows a scatter plot of students' pretest and posttest scores. Each point represents one student, with pretest scores on the x-axis and posttest scores on the y-axis. The diagonal line (y = x) serves as a reference for equal scores before and after the intervention. Most data points are above the diagonal, indicating that most students scored higher on the posttest than on the pretest. This finding visually confirms that the use of the Ethno–Collaborative Inquiry-Based Plane Figures Module was associated with improved student learning outcomes.

Table 10. Distribution of students' n-gain category

N-Gain Category	Number of Students	Percentage
High	6	15.79%
Medium	32	84.21%
Low	0	0.00%
Total	38	100%

Table 10 shows that 6 students, representing 15.79% of the participants, achieved N-Gain scores in the high category, while 32 students, or 84.21%, were classified in the moderate category. No students were classified in the low category. This distribution indicates that all participants improved after learning with the Ethno–Collaborative Inquiry-Based Plane Figures Module, although the magnitude of improvement varied among students. The predominance of the moderate category is consistent with the overall mean N-Gain score of 0.56. These findings provide complementary descriptive evidence of students' improvement in learning, while the statistical significance of the increase is confirmed by the paired-samples t-test presented in Table 9.

Figure 7 shows the distribution of N-Gain scores for 38 students after participating in instruction using the Ethno–Collaborative Inquiry-Based Plane Figures Module. The horizontal line within the box indicates the median N-Gain score of 0.56, while the triangle symbol indicates the mean value, which is also 0.56. The interquartile range is between 0.41 and 0.65, indicating that most students experienced a moderate improvement in learning outcomes. The lowest N-Gain score was around 0.33, while the highest

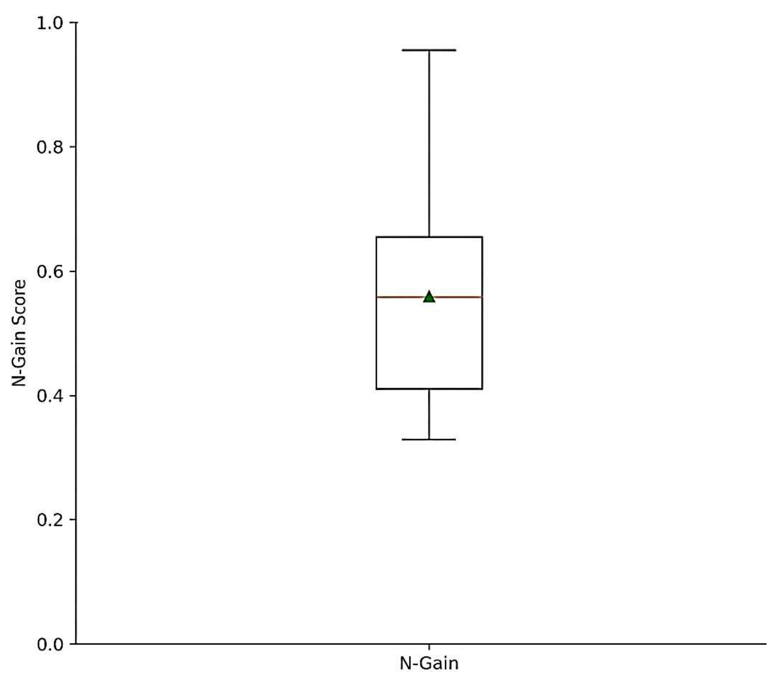

Figure 7. Distribution of students' n-gain category

reached approximately 0.95. This distribution shows that all students experienced an improvement in learning outcomes, although the degree of improvement varied. Overall, this pattern supports the finding that the developed module demonstrates initial effectiveness in enhancing students' understanding of plane figure concepts.

The research findings show that the Ethno–Collaborative Inquiry-Based Plane Figures Module can support the creation of more contextual and meaningful mathematics learning for elementary school students. The use of Sasak weaving motifs as an ethnomathematics context provides a learning experience closely tied to students' social and cultural environments, so that the concepts of plane figures are understood not only as abstract material but also as part of the community's cultural practices. This finding aligns with the perspective of Näslund-Hadley et al. (2025), who assert that ethnomathematics connects mathematical concepts to cultural activities in everyday life. Nasrum et al. (2025) also explain that culture-based mathematics learning can strengthen students' understanding because the material is linked to their real-life experiences and social contexts. In this study, Sasak weaving motifs, which feature squares, rectangles, triangles, repeating patterns, and symmetry, proved to be effective as concrete media for introducing and deepening students' understanding of geometric concepts.

The learning process facilitated through the Collaborative Inquiry approach enabled students to actively construct mathematical knowledge by observing cultural objects, formulating problems, making predictions, exploring patterns, analyzing findings, evaluating strategies, and reflecting on their learning outcomes. Throughout the learning sessions, students were not merely recipients of information. However, they actively engaged in group discussions, perimeter and area calculations, comparisons of problem-solving strategies, and the development of mathematical weaving-motif projects. This finding is consistent with Khan & Ahmed (2025), which argues that inquiry-based learning strengthens conceptual understanding by engaging students in investigation and problem-solving processes. It is also supported by Wen et al. (2023), who emphasize that collaborative learning promotes student engagement, communication, and shared responsibility in achieving learning objectives.

The improvement in students' learning outcomes can be attributed to the specific features incorporated into the Ethno–Collaborative Inquiry-Based Plane Figures Module. The use of Sasak weaving motifs provided a culturally familiar and visually concrete context that helped students connect abstract concepts of area, perimeter, symmetry, and composite figures with objects found in their everyday environment. In particular, the weaving-motif project conducted during the third session required students to creatively apply geometric concepts by designing patterns, identifying plane figures, and calculating their dimensions. This activity facilitated knowledge transfer by requiring students to apply previously learned concepts to a new, authentic, and meaningful task. These learning experiences reflect constructivist principles, which emphasize that conceptual understanding develops through active knowledge construction, social interaction, contextual problem solving, and reflection. Therefore, the observed improvement was supported by the integration of cultural relevance, guided inquiry, collaborative learning, and project-based application within the module.

CONCLUSION

Based on the research findings, the Ethno–Collaborative Inquiry-Based Plane Figures Module, developed using the ADDIE model, demonstrates initial effectiveness in supporting deep learning among primary school pupils. The integration of plane figure concepts with Sasak weaving motifs as an ethnomathematics context provides a more concrete, contextual, and meaningful learning experience. Through activities such as observing patterns, identifying geometric shapes, calculating perimeters and areas, engaging in collaborative discussions, and designing mathematical weaving-pattern projects, pupils were able to understand geometric concepts in a more practical way. The evaluation results show that the average student score increased from 51.55 on the pre-test to 78.29 on the post-test, with an N-Gain of 0.56, which falls within the moderate category. Nevertheless, the results of this study must be interpreted with caution, as the research was conducted in only one school, involved a relatively small sample of 38 pupils, and utilized a single-group pre-test–post-test design without a control group. These limitations mean that the generalisability of the research findings remains limited and do not yet allow for strong causal conclusions to be drawn regarding the effectiveness of the module. Further research is recommended to involve a broader, more diverse sample, include a comparison or control group, examine the long-term sustainability of pupils' conceptual understanding, and develop modules on other mathematical topics supported by interactive digital media.

DECLARATION OF GENERATIVE AI USAGE IN THE WRITING PROCESS

During the drafting and editing of this manuscript, the author used generative artificial intelligence tools to assist with language refinement, translation, sentence-structure adjustments, grammar, and the clarity of the text's presentation in accordance with academic standards. All content generated with the aid of these tools has been reviewed, verified, and re-edited by the author. The author takes full responsibility for the accuracy, originality, interpretation, and overall content of the published article.

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