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Development of a STEM-Based Teaching Module Integrated with Indigenous Knowledge of the Sade Traditional House to Improve Students' Geometry Problem-Solving Skills

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Abstract

This study aims to develop a Science, Technology, Engineering, and Mathematics (STEM)-based teaching module that integrates the Indigenous Knowledge of the Sade Traditional House into geometry curriculum and to test its validity, practicality, and effectiveness in improving students' problem-solving skills. This study employed the Research and Development (R&D) method using the ADDIE model, which includes the stages of analysis, design, development, implementation, and evaluation. The research subjects consisted of 69 students: 34 in the experimental class and 35 in the control class. The research instruments included an expert validation sheet, a student response questionnaire, and problem-solving ability tests in the form of pretests and posttests. The expert validation results showed a percentage of 88%, categorized as highly valid, while student responses yielded a percentage of 86.18%, categorized as highly practical. An analysis of learning outcomes showed that the average pretest score for the experimental class increased from 33.76 to 74.85 on the posttest, while the control class's score increased from 36.89 to 41.63. The results of the independent samples t-test showed a significant difference between the two classes on the posttest ($p < 0.001$), proving that the developed teaching module was effective in improving students' problem-solving skills. The integration of Indigenous Knowledge of the Sade Traditional House into geometry instruction created a contextual and meaningful learning experience and strengthened the connection between mathematical concepts and local culture.

Keywords: Teaching module; STEM; Indigenous knowledge; Sade traditional house; Geometry; Problem-solving skills

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INTRODUCTION

21st-century education identifies critical thinking, creativity, collaboration, communication, and problem-solving as the key competencies that students must possess (Park & Kwon, 2024; Khatri et al., 2024). In the context of mathematics learning, problem-solving skills are a key objective because students are expected to apply mathematical concepts to solve real-world problems in daily life (Looi et al., 2024; Imron et al., 2025). Technological advancements and global challenges demand learning that focuses not only on memorizing concepts but also on the ability to apply knowledge in context (Islam et al., 2024). Mathematics instruction must be designed innovatively to optimally develop students' higher-order thinking skills.

Students' mathematical problem-solving skills in Indonesia remain relatively low compared to those in other countries (Vessonen et al., 2024). Results from the Programme for International Student Assessment (PISA) indicate that most Indonesian students still struggle with solving problems that require reasoning, interpretation, and contextual problem-solving (Srikoon et al., 2024; Ulya et al., 2024). Students tend to be able to solve routine problems but face challenges when confronted with non-routine problems that require problem-solving strategies. This situation indicates that the mathematics learning process in schools has not yet fully succeeded in maximizing the development of students' higher-order thinking skills (Jäder et al., 2020; Chau et al., 2025). One of the mathematics topics that students find difficult is geometry. Geometry requires visualization skills, spatial reasoning, and the ability to connect abstract concepts with real-world shapes in the surrounding environment. However, in practice, geometry is often taught abstractly through formulas and symbols without providing students with contextual experiences (Rosiyanti et al., 2021). As a result, students struggle to understand geometric concepts and are less able to apply them to solving everyday problems

These issues highlight the need for innovation in mathematics education—particularly in geometry—through approaches that connect mathematical concepts to students' real-life experiences. One such approach is the STEM (Science, Technology, Engineering, and Mathematics) approach (Durrani & Kataeva, 2025; Ouyang & Xu, 2024). The STEM approach emphasizes the integration of various disciplines to solve real-world problems systematically and creatively (Halawa et al., 2024; Kayan-Fadlelmula et al., 2022). STEM learning encourages students to actively observe, design, test, and evaluate solutions to problems, thereby enhancing their critical thinking and problem-solving skills.

The STEM approach in mathematics education has great potential to improve the quality of geometry instruction (Chiu et al., 2025; Manalu & Chang, 2025). Through the STEM approach, students not only learn concepts theoretically but also apply them in design, construction, and contextual problem-solving activities (Xu & Ouyang, 2022; Chiu et al., 2025). This type of learning helps students understand the connection between mathematics and real life, making the learning experience more meaningful. Various studies show that STEM-based learning can improve students' learning outcomes, creativity, critical thinking skills, and mathematical problem-solving abilities.

In addition to the STEM approach, contextual learning based on local culture is also an important strategy for improving the quality of mathematics education (Kusno et al., 2024; Hatima, 2025). Integrating local culture into learning can help students understand concepts more concretely because they are directly related to their environment and life experiences (Talita & Saputra, 2025; Nuraini et al., 2025). Local culture-based learning can also strengthen students' cultural identity while serving as a means of preserving local wisdom amid the advance of globalization. Mathematics instruction needs to incorporate elements of local culture to make it more relevant to students' lives (Awang et al., 2025; Cotič et al., 2024). The concept of Indigenous Knowledge is a crucial component in the development of culture-based learning. Indigenous Knowledge refers to knowledge that has evolved within a specific community based on experience, traditions, and cultural values passed down through generations (Misnah et al., 2024; Suardana et al., 2018). In an educational context, Indigenous Knowledge can be utilized as a contextual and meaningful learning resource. Integrating Indigenous Knowledge into mathematics instruction can help students understand concepts through tangible cultural objects that are close to their daily lives.

In West Nusa Tenggara, particularly among the Sasak people of Lombok, there are various forms of local culture that embody mathematical values, one of which is the Sade traditional house (Rasel & Irawan, 2023). The Sade traditional house is a traditional dwelling of the Sasak people that features unique architectural characteristics and incorporates various geometric concepts. The shape of the roof, the building's structure, the floor patterns, and the house's construction demonstrate the presence of concepts such as plane figures, solid figures, symmetry, angles, and ratios (Talim et al., 2023; Mannan, 2019). This indicates that the Sade traditional house has great potential to serve as a context for contextual and locally-based geometry learning. Utilizing the Sade traditional house as a resource for mathematics learning can provide students with a more concrete learning experience (Sade & Suviste, 2020). Students can directly observe the geometric shapes found in traditional buildings, thereby making mathematical concepts less abstract. Furthermore, incorporating local cultural contexts into learning can boost students' motivation because the learning material feels more relevant to their lives. This approach also helps students understand that mathematics is present in the culture and daily lives of the community.

However, the reality on the ground shows that the use of local culture in mathematics education remains very limited. Teachers tend to use conventional teaching materials that focus on presenting content and providing practice problems without linking concepts to local culture or students' real-life experiences siswa (Djubaedi et al., 2024; Ratminingsih et al., 2020). As a result, learning becomes less engaging, and students struggle to understand the practical benefits of mathematics in their daily lives. Furthermore, instructional modules that integrate STEM approaches with Indigenous Knowledge remain scarce, particularly in geometry (Mardatillah et al., 2023; Listiyani et al., 2025). Instructional modules are a key component of the learning process because they serve as systematic learning guides for students (Maksum & Purwanto, 2022; Ding & Toran, 2024). A well-designed instructional module should facilitate independent, active, and contextual learning among students. In the Merdeka Curriculum, instructional modules are designed to make learning more flexible, student-centered, and relevant to the surrounding environment (Mat et al., 2025; Darmayanti & Khairunnisa, 2024). The development of STEM-based instructional modules integrated with Indigenous Knowledge is a strategic step in supporting the implementation of innovative and meaningful learning.

The development of a STEM-based teaching module that integrates Indigenous Knowledge of the Sade traditional house into geometry lessons is expected to help students understand geometric concepts in a more concrete and practical way (Markus et al., 2021; Aditia et al., 2024). Through this module, students not only learn about formulas and theories but are also trained to identify problems, design solutions, take measurements, and analyze geometric shapes in the Sade traditional house (Afifah et al., 2024; Ahsan, 2023). These activities can encourage students to think critically and systematically when solving mathematical problems. In addition to improving problem-solving skills, the development of teaching modules based on local culture also holds strategic value for the preservation of regional culture (Aswatudali et al., 2024; Laurah-Markus, 2022). In this era of modernization, the younger generation tends to be less familiar with their own local culture. Integrating local culture into learning can serve as an educational medium to introduce and instill cultural values in students from an early age. Mathematics education serves not only to transfer knowledge but also as a means of character building and the preservation of national culture.

Previous research has shown that both STEM-based learning and ethnomathematics-based learning, when implemented separately, have had a positive impact on students' problem-solving skills (Wahyu et al., 2020; Risnanosanti et al., 2024). However, research integrating STEM with the Indigenous Knowledge of the Sade traditional house in the form of teaching modules for geometry lessons remains very limited. This highlights the need to develop innovative teaching materials capable of integrating the STEM approach with local cultural contexts in a cohesive manner (Muzana et al., 2021). The development of these teaching modules is also aligned with the direction of national education policy, which emphasizes the importance of differentiated, contextual, and project-based learning. The Merdeka Curriculum provides teachers with the flexibility to design learning experiences tailored to students' characteristics and the potential of their local communities (Arwin et al., 2024; Lin et al., 2021). The integration of the Sade traditional house into STEM-based geometry instruction represents a form of contextual learning that supports the strengthening of the Pancasila learner profile, particularly in the dimensions of creativity, critical thinking, and global diversity.

This study aims to develop a STEM-based teaching module that integrates Indigenous Knowledge of the Sade Traditional House into geometry lessons to improve students' mathematical problem-solving skills. The developed module is designed to meet the criteria of validity, practicality, and effectiveness, as well as to facilitate contextual, meaningful, innovative, and culturally relevant geometry learning. Through the development of this module, students are expected to understand geometric concepts by exploring the shapes, structures, and mathematical values of the Sade Traditional House, while simultaneously strengthening 21st-century skills and supporting the implementation of the Merdeka Curriculum.

METHOD

This study is a research and development (R&D) project aimed at producing Science, Technology, Engineering, and Mathematics (STEM)-based teaching modules that integrate the Indigenous Knowledge of the Sade Traditional House into geometry curriculum content, as well as testing their validity, practicality, and effectiveness in improving students' problem-solving skills. The development model used is the ADDIE model developed by Branch, which consists of five stages: Analysis, Design, Development, Implementation, and Evaluation.

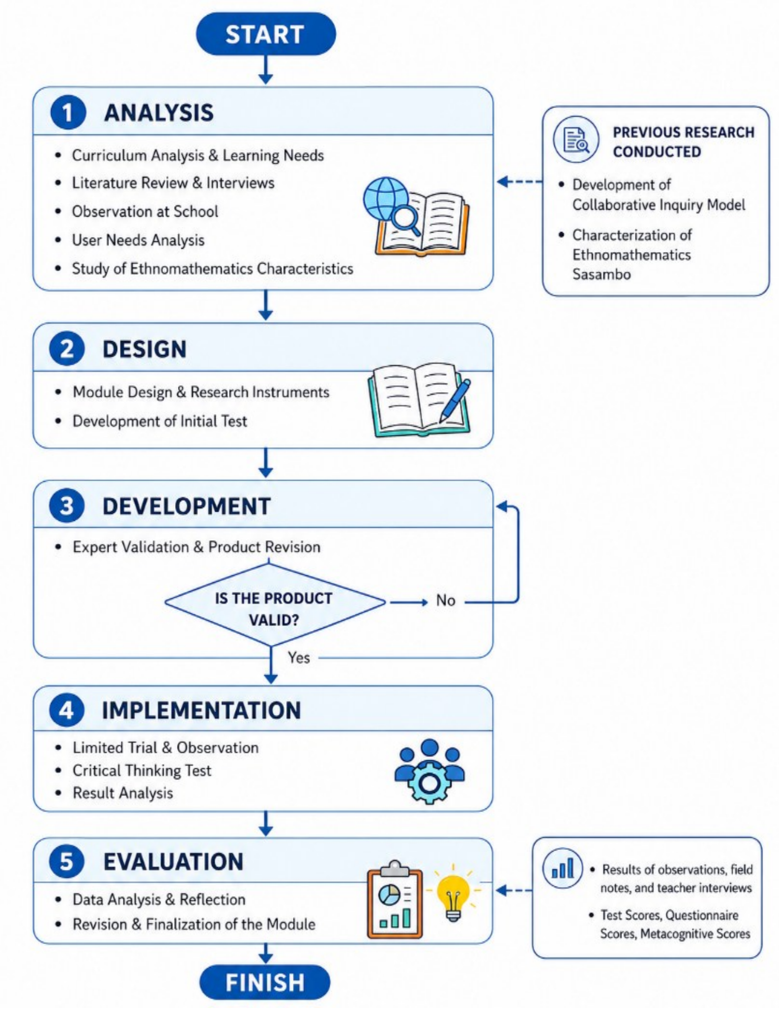

Figure 1. Research Flowchart

During the Analysis phase, a needs assessment was conducted through classroom observations, interviews with mathematics teachers, an analysis of student characteristics, a curriculum analysis based on the Merdeka Curriculum, an analysis of geometry content, and the identification of relevant Indigenous Knowledge from the Sade Traditional House that could be integrated into instruction. The results of the analysis indicate that geometry instruction remains abstract, the use of contextual teaching materials is still limited, and students' problem-solving skills remain low; therefore, the development of teaching modules that integrate the STEM approach with local wisdom is necessary.

The Design Phase includes the development of learning outcomes, learning objectives, a sequence of learning objectives, the development of geometry materials related to the structure of the Sade Traditional House, the development of STEM-based learning activities, the development of Student Worksheets (LKPD), the development of assessment instruments for problem-solving skills, the development of student response questionnaires and expert validation forms, as well as the design of the module interface to ensure it is engaging and user-friendly.

The development phase involved creating instructional modules based on the existing design, which were then validated by a team of validators consisting of subject matter experts, media experts, and learning experts. Validation is conducted to assess aspects of content, presentation, language, graphics, STEM integration, and the integration of Indigenous Knowledge. The validation results showed a feasibility rate of 88%, placing the module in the "highly valid" category and deeming it suitable for use in the learning process after revisions are made in accordance with the validators' recommendations.

The implementation phase was conducted with 69 tenth-grade students in Phase E at Jonggat State High School 1, consisting of 34 students in the experimental class and 35 students in the control class. The experimental class used a STEM-based teaching module that integrated the Indigenous Knowledge of the Sade Traditional House, while the control class followed conventional teaching methods using the materials typically used by teachers.

Research Subjects and Sampling Techniques

The subjects of this study were 69 tenth-grade students at SMAN 1 Jonggat, consisting of 34 students in the experimental class and 35 students in the control class. Subjects were selected using purposive sampling, taking into account the students' comparable initial abilities and the relatively homogeneous class conditions. The use of purposive sampling in this study was based on practical and methodological considerations, given that the research was conducted within the context of real-world learning in a school setting. To minimize potential bias, external variables—such as the similarity of instructional materials, the timing of implementation, and the learning environment—were controlled for between the experimental and control classes.

Research Variables

This study involves two types of variables: independent variables and dependent variables. The independent variable is the use of STEM-based teaching modules that integrate the Indigenous Knowledge of the Sade Traditional House. The dependent variable is students' problem-solving skills in geometry.

Research Instruments

The instruments used in this study included an expert validation sheet, a student response questionnaire, and a student problem-solving ability test. The validation sheets were used to assess the validity of the modules in terms of content, presentation, language, and appearance. The student response questionnaires were used to determine the practicality of the modules after they were used in the learning process. The problem-solving ability tests were used to measure students' problem-solving abilities before and after learning with the instructional modules.

Data Collection and Analysis Techniques

Research data were collected through observation, questionnaires, and tests. Validity data were obtained through expert assessment, practicality data were obtained through student response questionnaires, and effectiveness data were obtained through Problem-Solving Ability tests. Data analysis was conducted using both descriptive and inferential methods.

Descriptive analysis was used to describe the levels of validity and practicality, as well as students' problem-solving ability scores. Inferential analysis was conducted using an independent t-test to determine differences between the experimental and control classes. Before hypothesis testing, assumption tests—including tests of normality and homogeneity of variance were performed. Data analysis was conducted using statistical software to ensure the accuracy of the research results.

Methodological Considerations

Methodologically, this study was designed to ensure that the results obtained reflect the impact of the intervention. Although it employs a quasi-experimental design, this study seeks to minimize bias by controlling for external variables and using validated instruments. Thus, the study's results are expected to possess an adequate level of validity in explaining the relationship between the use of a STEM-based teaching module integrated with indigenous knowledge of the Sade traditional house and improvements in students' problem-solving skills.

RESULTS AND DISCUSSION

This section presents the research findings obtained through the development of a STEM-Based Teaching Module Integrated with Indigenous Knowledge of the Sade Traditional House for geometry instruction. This teaching module was developed as an effort to provide instructional materials that are not only focused on conceptual mastery but also capable of facilitating students in developing contextual mathematical problem-solving skills. The developed teaching module was designed to integrate elements of Science, Technology, Engineering, and Mathematics into learning activities, while utilizing the Sade Traditional House as a local cultural context that embodies various geometric concepts. Through this integration, students are expected to understand geometric concepts in a more concrete, practical, and meaningful way, as the concepts studied are directly linked to cultural objects that are integral to the daily lives of the local community. The presentation of the research results is organized based on the ADDIE model, which consists of five main stages: Analysis, Design, Development, Implementation, and Evaluation.

Analysis Stage

The analysis phase was conducted to identify learning needs, students' initial conditions, the instructional materials used, and the potential for integrating Indigenous Knowledge of the Sade Traditional House into geometry instruction. Observations of 10th-grade students at Jonggat State High School 1 revealed that students' mathematical problem-solving skills were still relatively low. Students struggled to understand problems, determine solution strategies, and apply geometric concepts to contextual situations.

The observations also revealed that geometry instruction still relies on standard textbooks and worksheets that do not integrate either the STEM approach or local culture. Interviews with teachers and students reinforced these findings, indicating that students continue to struggle with understanding the concepts of area and volume, connecting mathematics to real life, and applying geometric concepts to objects in their surroundings. Therefore, a teaching module is needed that integrates Science, Technology, Engineering, Mathematics, and the Indigenous Knowledge of the Sade Traditional House to make learning more contextual and meaningful.

Design Stage

The design phase was conducted based on the results of the needs analysis obtained in the previous phase. In this phase, the researcher developed a preliminary design for the teaching module, the instructional design, and the research instruments to be used to assess the quality of the product. The design process took into account student characteristics, learning outcomes, learning objectives, the characteristics of geometry material, the STEM approach, and the values of Indigenous Knowledge found in the Sade Traditional House.

The structure of the designed teaching module includes several main components: module identity, learning outcomes, learning objectives, concept maps, content descriptions, STEM activities, worksheets, learning reflections, and evaluation tests. Each component is systematically organized to guide teachers and students in conducting focused geometry instruction. The material in the module not only provides theoretical explanations of concepts but also relates geometric concepts to the shapes, structures, and construction of the Sade Traditional House.

The instructional design in this module is based on the STEM approach. The learning sequence is structured around several key activities: identifying problems, observing the Sade Traditional House, determining relevant geometric concepts, designing solutions, calculating area and volume, and presenting the results. Through these stages, students are guided to actively build conceptual understanding through the processes of observation, exploration, analysis, and problem-solving. The learning activities are also designed to enable students to work collaboratively, engage in discussions, and communicate their problem-solving results.

At this stage, research instruments were also developed to assess the quality of the instructional module. These instruments include a subject matter expert validation sheet, a media expert validation sheet, a language expert validation sheet, a student response questionnaire, a teacher response questionnaire, and a mathematical problem-solving skills test. The validation forms are used to assess the suitability of the modules in terms of content, presentation, language, graphics, the appropriateness of the STEM approach, and the integration of Indigenous Knowledge from the Sade Traditional House. Meanwhile, the response questionnaires are used to determine the practicality of the modules, while the problem-solving ability test is used to assess the modules' effectiveness in improving students' problem-solving skills.

Development Stage

The development phase involved creating initial products based on the existing design. The products developed included STEM-based teaching modules, worksheets, visual materials on the Sade Traditional House, problem-solving tests, and research instruments. The modules were developed by linking geometric concepts to the shapes, structures, and mathematical elements found in the Sade Traditional House.

The initial products were then validated by subject matter experts, media experts, and language experts. Validation was conducted to assess the appropriateness of the content, presentation, language, STEM integration, and the suitability of the integration of Indigenous Knowledge. Feedback from the validators was used as the basis for revising the products until the modules were deemed suitable for implementation in the classroom.

Implementation Stage

The implementation phase began after the teaching module was approved by the validator. During this phase, the module was implemented in geometry classes for 10th-grade students at Jonggat 1 Public High School. Implementation activities included administering a pretest, conducting lessons using the module, completing STEM activities and worksheets, and administering a posttest.

During the lessons, students were guided to observe geometric elements in the Sade Traditional House, relate them to the concepts of area and volume, and solve contextual problems. After the lessons were completed, students and teachers filled out response questionnaires to assess the module's practicality. Pre-test and post-test data were used to evaluate the module's effectiveness in improving students' mathematical problem-solving skills.

Validity Results of the Teaching Module

The validity of the teaching module was determined through an evaluation by three validators, including a subject matter expert, a media expert, and a learning expert. The evaluation assessed the following aspects: Content Appropriateness, STEM Integration, Indigenous Knowledge of the Sade Traditional House, Problem-Solving Skills, Visual Design, Presentation, and Language. The validation results are presented in Table 1.

Table 1. Results of Expert Validation of the STEM-Based Teaching Module Integrating Indigenous Knowledge of the Sade Traditional House in the Geometry Curriculum.

Validator	Validity Percentage	Validity Category	Brief Description
X1	86 %	Very valid	The questions provided should be more closely linked to local elements of the Sade traditional house.
X2	91 %	Very valid	Each question should be answered in a way that reinforces STEM concepts.
X3	87 %	Very valid	It would be more effective to include supporting videos related to integrated STEM learning about the Sade traditional house.
average	**88 %**	**Very valid**	The module is suitable for use with minor revisions based on the validator's suggestions.

Table 1 shows that, based on the validation results from three validators, the STEM-based teaching module integrating Indigenous Knowledge of the Sade Traditional House achieved an average validity percentage of 88%, falling into the "highly valid" category. Validator X1 assigned a score of 86% and suggested that the questions be more closely linked to local elements of the Sade Traditional House; validator X2 assigned a score of 91% and recommended that the solutions to the questions further reinforce STEM elements; and validator X3 assigned a score of 87% and suggested adding supplementary instructional videos. Thus, the developed teaching module was deemed suitable for use in geometry instruction with minor revisions based on the validators' feedback.

Results of the Practical Application of the Teaching Module

The practicality of the teaching module was assessed through a student feedback questionnaire administered after the module was used in the classroom. The assessment focused on six main aspects: the module's design, the presentation of the material, the integration of STEM, indigenous knowledge of the Sade traditional house, problem-solving skills, and motivation to learn. The results of the student feedback are presented in Table 2.

Table 2. Percentage of Student Responses Regarding the Practicality of the STEM-Based Teaching Module Integrating Indigenous Knowledge of the Sade Traditional House in the Geometry Curriculum.

No	Statement	SS	S	CS	TS	STS
A.	**Visual Aspects of the Module**					
1	The module's cover design caught my attention.	20	10	2	2	0
2	The color scheme of the module is easy on the eyes.	21	9	3	1	0
3	The font used is easy to read.	30	2	1	1	0
4	The images in the module are clear and engaging.	28	2	2	2	0
5	The layout of the material is neat and systematic.	25	4	3	2	0
B.	**Presentation of the Material**					
6	The geometry material in the module is easy to understand.	20	8	3	3	0
7	The examples provided helped me understand the material.	18	10	3	3	0
8	The language used is easy to understand.	16	12	2	4	0
9	The instructions for using the module are easy to understand.	28	2	2	2	0
10	The order in which the material is presented helps me learn independently.	15	10	5	3	1
C.	**Aspects of STEM Integration**					
11	The activities in the module helped me understand the relationship between science and geometry.	16	10	4	3	1

No	Statement	SS	S	CS	TS	STS
12	The use of technology in learning made me more interested in learning.	17	9	3	3	2
13	The engineering activities made me a more active learner.	15	8	7	2	2
14	The mathematical concepts in the module were presented clearly.	20	10	2	1	1
15	STEM integration makes learning more engaging than traditional learning.	18	10	2	2	2
D.	**Aspects of Indigenous Knowledge in the Sade Traditional House**					
16	I gained a better understanding of the Sade Traditional House after using this module.	20	5	5	2	2
17	The geometry concepts related to the Sade Traditional House were easier to understand.	16	8	5	5	0
18	The local wisdom of the Sade Traditional House made learning more meaningful.	14	14	2	4	0
19	I am interested in learning about local culture through mathematics.	16	14	2	2	0
20	Using the Sade Traditional House as a learning context made me more motivated to learn.	17	13	3	1	0
E.	**Problem-Solving Skills**					
21	The module helped me understand the problems presented.	15	14	3	2	0
22	The module helped me plan strategies for solving problems.	14	16	3	1	0
23	The module helped me solve geometry problems systematically.	16	14	3	1	0
24	The module helped me double-check my answers.	12	14	4	4	0
25	After using the module, my problem-solving skills have improved.	18	8	6	1	1
F.	**Aspects of Learning Motivation**					
26	I am more motivated to learn math using this module.	17	13	2	1	1
27	I am interested in participating in all the activities in the module.	18	12	1	2	1
28	The module makes me more active in the learning process.	15	15	1	1	2
29	I would like to use a similar module for other subjects.	21	8	3	1	1
30	Overall, I like this module.	20	8	4	1	1

Based on the data from the student response questionnaire, the average percentage for each aspect is shown in Table 3.

Table 3. Average percentage of student responses for each aspect regarding the practicality of the STEM-based teaching module integrating indigenous knowledge of the Sade Traditional House in the geometry curriculum.

Aspect	Number of Items	Average Percentage for Each Aspect	Category
A. Module Design	5	91,41%	Very Practical
B. Presentation of Material	5	85,76%	Very Practical
C. STEM Integration	5	84,47%	Very Practical
D. Indigenous Knowledge of the Sade Traditional House	5	85,41%	Very Practical
E. Problem-Solving Skills	5	84,12%	Very Practical
F. Motivation to Learn	5	85,88%	Very Practical

Formula Used

The score for each item is calculated using the following formula:

$$\text{Score} = (SS \times 5) + (S \times 4) + (CS \times 3) + (TS \times 2) + (STS \times 1)$$

Since there were 34 students in the sample, the maximum score for each item is:

$$34 \times 5 = 170$$

The percentage for each item is calculated as follows:

$$\text{Percentage} = \frac{\text{Scores obtained}}{170} \times 100\%$$

The overall average for all aspects is: $\frac{91{,}41+85{,}76+84{,}47+85{,}41+84{,}12+85{,}88}{6} = 86{,}18\%$

Based on the results of the student response questionnaire analysis in Table 3, the STEM-based teaching module integrating Indigenous Knowledge of the Sade Traditional House received a response rate of 86.18%, which falls into the "Very Practical" category. This percentage indicates that, in general, students gave a very positive evaluation of the developed module.

The high student response rate indicates that the module has a good level of usability, in terms of its appearance, presentation of material, and readability. Furthermore, the integration of the STEM approach with Indigenous Knowledge of the Sade Traditional House enables more contextual learning, thereby helping students understand geometric concepts through phenomena that are close to their daily lives and culture.

Positive feedback was also evident regarding the design of learning activities that encouraged students to observe, analyze, discuss, and solve problems systematically. These activities made students more active during the learning process and increased their motivation to learn. Furthermore, the inclusion of illustrations, contextual examples, and structured worksheets helped students follow each stage of the learning process more easily.

The practicality percentage of 86.18% indicates that the module is not only suitable for use but also easy to understand, engaging, and helpful to students in the learning process. Thus, the developed instructional module has met the practicality aspect as one of the main criteria in development research. These results also reinforce the finding that modules with a validity rate of 88% can be effectively implemented in the classroom, as they are not only deemed suitable by experts but also receive very positive feedback from users—namely, the students.

Results on the Effectiveness of the Teaching Module

The effectiveness of the Science, Technology, Engineering, and Mathematics (STEM)-based teaching module, which integrates the Indigenous Knowledge of the Sade Traditional House, was measured by assessing the improvement in students' problem-solving skills following the learning process. The assessment was conducted using a problem-solving skills test administered before instruction (pretest) and after instruction (posttest) in both the experimental and control classes.

Table 4. Group Statistics

	Class	N	Mean	Std. Deviation	Std. Error Mean
GPSS_Pretest	Experimental	34	33.76	13.848	2.375
	Control	35	36.89	14.117	2.386

Table 4 shows the descriptive statistics for the pretest scores on geometric problem-solving skills of students in the experimental and control classes. Based on the table, the experimental class consisted of 34 students with a pretest mean score of 33.76, a standard deviation of 13.848, and a standard error of the mean of 2.375. Meanwhile, the control class consisted of 35 students with a pretest mean score of 36.89, a standard deviation of 14.117, and a standard error of the mean of 2.386. Descriptively, the control class's pretest mean score was slightly higher than that of the experimental class. However, the difference in the means between the two groups was relatively small, at 3.13 points. The standard deviations for both groups were also nearly equal, indicating that the distribution of pretest scores between the experimental and control classes was relatively similar. Thus, the baseline data suggest that the students' initial abilities in both groups were at a relatively comparable level before the instructional intervention was administered.

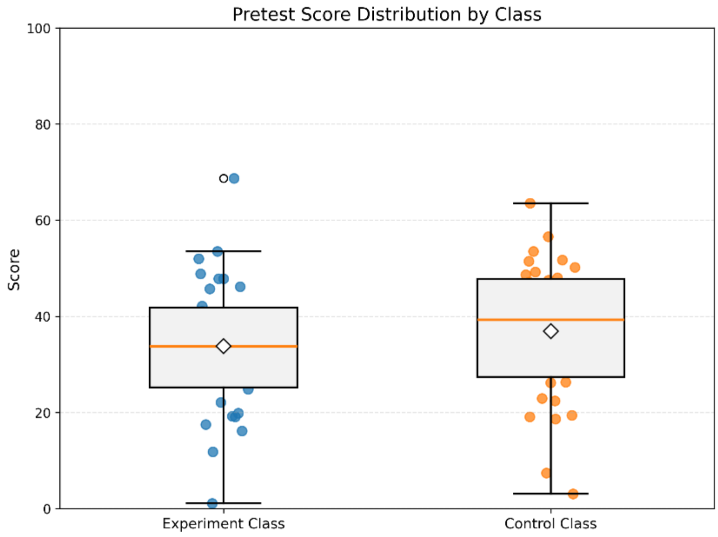

Figure 2. Distribution of Pretest Scores by Class

Figure 2 shows the distribution of pretest scores in the experimental and control classes. Descriptively, the median pretest score for the control class appears slightly higher than that of the experimental class. However, the score distributions of the two groups are relatively close, suggesting that the students' initial abilities in both classes were comparable before the instructional intervention was implemented. The boxplots also reveal score variation within each group but do not indicate any particularly striking initial differences from a descriptive perspective.

Table 5. Tests of Normality

	Class	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
Pretest	Experimental	.166	34	.018	.924	34	.021
	Control	.105	35	.200*	.944	35	.074

*. This is a lower bound of the true significance.
a. Lilliefors Significance Correction

Table 5 presents the results of the normality test for pretest scores in the experimental and control classes using the Kolmogorov–Smirnov and Shapiro–Wilk tests. Based on the results of the Shapiro Wilk test, the experimental class obtained a significance value of 0.021, while the control class obtained a significance value of 0.074. Since the sample size in each group was less than 50, the primary interpretation is more appropriately based on the results of the Shapiro Wilk test. The significance value for the experimental class is less than 0.05, indicating that the pretest data for the experimental class are not normally distributed. Meanwhile, the significance value for the control class is greater than 0.05, indicating that the pretest data for the control class are normally distributed. It can be concluded that the assumption of normality is not fully met because one of the groups—the experimental class—exhibits a non-normal data distribution.

Table 6. Tests of Homogeneity of Variances

		Levene Stat.	df1	df2	Sig.
Pretest	Based on Mean	.003	1	67	.958
	Based on Median	.011	1	67	.917
	Based on Median and with adjusted df	.011	1	66.497	.917
	Based on trimmed mean	.000	1	67	.985

Table 6 presents the results of the homogeneity of variance test for pretest scores using Levene's Test. Based on the analysis in the "Based on Mean" row, the Levene statistic was 0.003 with a p-value of 0.958. Since this p-value is greater than 0.05, it can be concluded that the variances of the pretest scores between the experimental and control classes are homogeneous. Similar results were also shown in the tests based on the median, the median with adjusted degrees of freedom, and the trimmed mean, all of which had significance values greater than 0.05. The assumption of homogeneity of variance in the pretest data has been met. This indicates that both groups had relatively comparable initial score variability before the instructional treatment was administered.

Tabel 7. Independent Samples Test

Assumption	Levene's F	Sig.	t	df	One-Sided p	Two-Sided p	Mean Diff.	SE Diff.	95% CI Lower	95% CI Upper
Equal var. assumed	.003	.958	-.927	67	.179	.357	-3.121	3.368	-9.843	3.601
Equal var. not assumed			-.927	66.993	.179	.357	-3.121	3.367	-9.841	3.599

Table 7 shows the results of the independent samples t-test to determine differences in problem-solving ability between the experimental and control classes based on pretest scores. Based on the results of Levene's Test for Equality of Variances, a significance value of 0.958 was obtained. This value is greater than 0.05, so it can be concluded that the variances of the two groups are homogeneous. Therefore, the interpretation of the t-test results refers to the "Equal variances assumed" row. The t-test results show a t-value of -0.927 with 67 degrees of freedom and a two-tailed significance level of 0.357. Since this significance level is greater than 0.05, there is no significant difference between the experimental and control classes in their initial problem-solving abilities. The mean difference between the two groups of -3.121 indicates that the mean score of the experimental class is slightly lower than that of the control class; however, this difference is not statistically significant. It can be concluded that the students' initial problem-solving abilities in both groups were relatively equivalent before the instructional intervention was administered.

Table 8. Group Statistics

	Class	N	Mean	Std. Deviation	Std. Error Mean
Postest	Experimental	34	74.85	14.300	2.452
	Control	35	41.63	15.170	2.564

Table 8 shows the descriptive statistics for the posttest scores on geometric problem-solving skills of students in the experimental and control classes. Based on the table, the experimental class consisted of 34 students with a mean posttest score of 74.85, a standard deviation of 14.300, and a standard error of the mean of 2.452. Meanwhile, the control class consisted of 35 students with a posttest mean score of 41.63, a standard deviation of 15.170, and a standard error of the mean of 2.564. Descriptively, the mean posttest score of the experimental class was significantly higher than that of the control class, with a mean difference of 33.22 points. This indicates that students in the experimental class achieved better learning outcomes after participating in the instruction provided. The standard deviations for both groups were relatively close, suggesting that the variation in posttest scores between the experimental and control classes was fairly comparable. These descriptive data indicate a difference in geometric problem-solving ability between the two groups following the instructional intervention.

Figure 3. Distribution of Posttest Scores by Class

Figure 3 shows the distribution of posttest scores in the experimental and control classes. Descriptively, the posttest scores of the experimental class appear higher than those of the control class, as indicated by the median position and the distribution of data within a higher score range. In contrast, the control class has a lower median with a fairly wide range of scores. These findings indicate that after the instructional intervention, the experimental class achieved better performance in geometric problem-solving skills compared to the control class.

Table 9. Tests of Normality

	Class	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
		Statistic	**df**	**Sig.**	**Statistic**	**df**	**Sig.**
Postest	Experimental	.120	34	.200*	.962	34	.275
	Control	.172	35	.010	.950	35	.112

*. This is a lower bound of the true significance.
a. Lilliefors Significance Correction

Table 9 presents the results of the normality test for posttest scores in the experimental and control classes using the Kolmogorov–Smirnov and Shapiro–Wilk tests. Based on the results of the Shapiro–Wilk test, the experimental class obtained a significance value of 0.275, while the control class obtained a significance value of 0.112. Since the sample size in each group was less than 50, the primary interpretation is based on the results of the Shapiro–Wilk test. The significance values for both groups were greater than 0.05; therefore, it can be concluded that the posttest data for the experimental and control classes are normally distributed. The assumption of normality for the posttest data has been met, so the data can be further analyzed using parametric statistical tests.

Table 10. Tests of Homogeneity of Variances

		Levene Stat.	df1	df2	Sig.
Postest	Based on Mean	.209	1	67	.649
	Based on Median	.191	1	67	.663
	Based on Median and with adjusted df	.191	1	66.770	.663
	Based on trimmed mean	.210	1	67	.649

Table 10 presents the results of the homogeneity of variance test for posttest scores using Levene’s Test. Based on the analysis in the “Based on Mean” row, the Levene statistic was 0.209 with a p-value of 0.649. Since this p-value is greater than 0.05, it can be concluded that the variances of the posttest scores between the experimental and control classes are homogeneous. Similar results were also observed in the tests based on the median, the median with adjusted degrees of freedom, and the trimmed mean, all of which showed significance values greater than 0.05. Thus, the assumption of homogeneity of variances in the posttest data has been met, allowing the analysis of the difference in means between the two groups to proceed using a parametric test, specifically the independent samples t-test under the assumption of equal variances.

Tabel 11. Independent Samples Test

Assumption	**Levene's F**	**Sig.**	**t**	**df**	**One-Sided p**	**Two-Sided p**	**Mean Diff.**	**SE Diff.**	**95% CI Lower**	**95% CI Upper**
Equal var. assumed	.209	.649	9.356	67	< .001	< .001	33.224	3.551	26.136	40.313
Equal var. not assumed			9.364	66.941	< .001	< .001	33.224	3.548	26.142	40.307

Table 11 presents the results of an independent samples t-test to determine differences in geometric problem-solving ability between the experimental and control classes based on posttest scores. Based on the results of Levene's Test for Equality of Variances, a significance value of 0.649 was obtained. This value is greater than 0.05, so the variances of the two groups are considered homogeneous. The interpretation of the t-test results refers to the "Equal variances assumed" row. The t-test results show a t-value of 9.356 with 67 degrees of freedom and a two-tailed significance level of <0.001. Since this significance level is less than 0.05, there is a significant difference between the experimental and control classes in geometric problem-solving ability after the intervention was administered. The mean difference of 33.224 indicates that the mean posttest score of the experimental class was higher than that of the control class. It can be concluded that the instructional approach used in the experimental class had a significant effect on improving students' geometric problem-solving skills compared to the instructional approach in the control class.

Evaluation Stage

The evaluation stage is the final stage in the module development process, aimed at comprehensively assessing the quality of the product. Evaluations are conducted both formatively and summatively to ensure that the developed module is not only theoretically sound but also aligned with classroom learning needs. Formative evaluation takes place throughout the development process through review, revision, and refinement of the product based on feedback from expert validators, teachers, and students. This feedback is used to improve several components of the module, including the accuracy of the content, the structure of the presentation, the visual design, the use of language, the clarity of instructions, the appropriateness of learning activities, and the integration of STEM elements and the Indigenous Knowledge of the Sade Traditional House into the geometry material.

A summative evaluation was conducted after the module was implemented in the classroom. This evaluation aimed to determine the module's validity, practicality, and effectiveness. The module's validity was assessed through expert evaluation of its content, presentation, language, design, and alignment between the STEM approach, the cultural context of the Sade Traditional House, and the geometry learning objectives. The practicality of the module is analyzed based on teacher and student response questionnaires after the module is used in the learning process. Meanwhile, the effectiveness of the module is assessed by measuring improvements in student performance through a comparison of pretest and posttest scores. Data obtained from the validation results, user feedback, and learning outcome tests are then analyzed to determine the final quality of the module.

The evaluation results were used as the basis for making final revisions to the module before it was finalized. Thus, the evaluation stage played a crucial role in ensuring that the STEM-Based Teaching Module Integrating Indigenous Knowledge of the Sade Traditional House met the necessary quality standards as a geometry teaching resource. The resulting final product is expected to meet the criteria of being valid, practical, and effective, so that it can be used to support contextual, meaningful, and culturally relevant geometry learning for students.

Discussion

The findings of this study indicate that the STEM-based teaching module integrated with the Indigenous Knowledge of the Sade Traditional House met the criteria of being valid, practical, and effective for geometry instruction. The expert validation result of 88% suggests that the module had appropriate content, presentation, language, visual design, STEM integration, and cultural relevance. This finding is important because a teaching module cannot be considered suitable only because it contains accurate mathematical content; it must also provide a clear learning sequence, meaningful activities, and accessible instructions for students. In this study, the module was designed not merely as a collection of geometry materials and exercises, but as a structured learning resource that connects geometry concepts with observation, measurement, design, and contextual problem-solving activities. This is consistent with the view that effective teaching modules should support independent learning, provide systematic guidance, and help students engage actively with learning tasks (Maksum & Purwanto, 2022; Ding & Toran, 2024; Mat et al., 2025).

The validity of the module also reflects the appropriateness of integrating STEM with local cultural knowledge in geometry learning. The validators' suggestions, such as strengthening the connection between questions and the local elements of the Sade Traditional House, reinforcing STEM concepts in problem solutions, and adding supporting instructional videos, show that the module still required minor refinement. However, these suggestions did not challenge the feasibility of the product. Instead, they strengthened the module's instructional quality by making the relationship between geometry, STEM activities, and Indigenous Knowledge more explicit. This aligns with previous studies showing that Ethno-STEM-based learning tools can connect cultural heritage with STEM education and support more contextual learning experiences (Listiyani et al., 2025; Aditia et al., 2024).

The practicality result, with an average student response of 86.18%, indicates that students perceived the module as easy to use, interesting, and helpful for learning geometry. The highest response was found in the visual aspect of the module, suggesting that design, layout, images, and readability supported students' engagement with the material. However, practicality should not be interpreted only from the attractiveness of the module. The more important point is that students responded positively to the integration of STEM activities, Indigenous Knowledge, problem-solving stages, and learning motivation. This means that the module was not only visually acceptable but also pedagogically usable in classroom practice. Similar findings have been reported in studies on STEM and culturally integrated learning materials, where contextual design and local content helped students understand abstract concepts more meaningfully (Misnah et al., 2024; Suardana et al., 2018; Ratminingsih et al., 2020).

The effectiveness of the module was shown by the significant improvement in students' geometry problem-solving skills. The experimental class increased from a pretest mean score of 33.76 to a posttest mean score of 74.85, while the control class increased only from 36.89 to 41.63. The independent samples t-test on posttest scores showed a significant difference between the experimental and control classes, $t(67) = 9.356$, $p < 0.001$. This result indicates that students who learned using the STEM-based module integrated with the Indigenous Knowledge of the Sade Traditional House performed better in geometry problem-solving than students who learned through conventional instruction. This finding is consistent with studies showing that STEM-based learning can improve students' mathematical literacy, learning achievement, and problem-solving skills because it requires students to connect concepts, investigate problems, design solutions, and evaluate results (Muzana et al., 2021; Srikoon et al., 2024; Halawa et al., 2024).

The improvement in the experimental class can be explained by the contextual nature of the learning activities. Geometry is often difficult for students because it involves abstract concepts, spatial reasoning, visualization, and the ability to connect formulas with real objects.

When geometry is taught only through symbols, formulas, and routine exercises, students may understand procedures but struggle to apply concepts to real-world situations. In this module, the Sade Traditional House served as a concrete cultural object through which students could identify plane figures, solid figures, angles, symmetry, area, volume, and proportional relationships. This contextualization helped students move from abstract mathematical representation to meaningful interpretation. Previous research also emphasizes that mathematical problem-solving improves when students are exposed to contextual tasks that require interpretation, reasoning, and application rather than memorization alone (Jäder et al., 2020; Ulya et al., 2024; Looi et al., 2024).

The integration of Indigenous Knowledge also contributed to the meaningfulness of learning. The Sade Traditional House is not only an architectural object but also a cultural product that reflects local wisdom, traditional construction knowledge, spatial organization, and community values. By using this context, students were encouraged to see mathematics as part of their cultural environment rather than as a detached school subject. This is important because local culture-based learning can increase students' awareness that mathematical ideas are embedded in daily practices, artifacts, and traditional knowledge systems. The finding supports previous studies that emphasize the role of Indigenous Knowledge and local culture in creating contextual learning, strengthening cultural identity, and helping students understand scientific or mathematical concepts through familiar cultural references (Misnah et al., 2024; Kusno et al., 2024; Talita & Saputra, 2025).

The STEM components in the module also appear to have strengthened students' problem-solving processes. Science was reflected in students' observation of the structure and function of the Sade Traditional House. Technology was represented through the use of visual materials and learning media to support exploration. Engineering appeared in activities that required students to analyze structure, design solutions, and consider construction-related problems. Mathematics served as the foundation for measuring, calculating, comparing, and solving geometry problems. This integration is relevant because STEM learning is not simply the combination of four disciplines, but a learning approach that encourages students to solve problems through interdisciplinary reasoning. This interpretation is in line with studies showing that STEM learning becomes effective when students are actively involved in observing, designing, testing, evaluating, and communicating solutions (Kayan-Fadlelmula et al., 2022; Lin et al., 2021; Ouyang & Xu, 2024).

Another important finding is that the experimental and control classes had relatively comparable initial abilities before the intervention. The pretest mean scores were 33.76 for the experimental class and 36.89 for the control class, and the independent samples t-test showed no significant difference between the two groups before instruction. This strengthens the interpretation that the difference in posttest performance was related to the instructional intervention. Even so, the pretest normality result showed that the experimental class data were not normally distributed. Therefore, the conclusion should still be presented with appropriate caution. The posttest data met the assumptions of normality and homogeneity, which supports the use of the independent samples t-test for determining differences after the intervention. However, future studies would benefit from additional analyses such as N-gain, effect size, or ANCOVA to provide stronger evidence regarding the magnitude of the module's effect.

The findings also have implications for the implementation of the Merdeka Curriculum. The module supports student-centered, contextual, and project-oriented learning by allowing students to explore geometry through local cultural objects. This is relevant to the curriculum's emphasis on meaningful learning, differentiated instruction, and the development of students' critical thinking, creativity, collaboration, and communication. The module also supports the strengthening of the Pancasila learner profile, particularly in relation to critical reasoning, creativity, and appreciation of cultural diversity. Previous studies have shown that learning materials aligned with local contexts and student characteristics can help teachers design more flexible and meaningful classroom practices (Darmayanti & Khairunnisa, 2024; Arwin et al., 2024; Nuraini et al., 2025).

Despite these positive findings, this study has several limitations. First, the implementation was conducted in one school with a limited sample of 69 students, so the findings cannot yet be generalized broadly to different school contexts. Second, the study focused on geometry problem-solving skills, while other relevant outcomes such as mathematical communication, creativity, collaboration, cultural awareness, and long-term retention were not examined. Third, the module's effectiveness was measured mainly through pretest and posttest scores, so future research should include classroom observation data, student work analysis, interviews, or learning process documentation to provide a deeper explanation of how students solve problems using the module. Future studies should also compare this module with other contextual or ethnomathematics-based approaches to determine which instructional components contribute most strongly to students' learning gains.

Based on these findings, the STEM-based teaching module integrated with the Indigenous Knowledge of the Sade Traditional House can be considered a relevant instructional innovation for geometry learning. Its strength lies in its ability to connect abstract geometry concepts with local cultural artifacts, while also guiding students through STEM-oriented problem-solving activities. The module does not only improve students' geometry problem-solving performance, but also provides a learning experience that is culturally meaningful and aligned with the needs of 21st-century education. Therefore, this module has potential for broader use and further development, especially in mathematics learning contexts that aim to integrate local wisdom, STEM education, and contextual problem-solving.

CONCLUSION

Based on the research findings, it can be concluded that this study successfully produced a Science, Technology, Engineering, and Mathematics (STEM)-based teaching module that integrates Indigenous Knowledge of the Sade Traditional House into geometry lessons to enhance students' problem-solving skills. The teaching module was developed using the ADDIE model, which includes the stages of Analysis, Design, Development, Implementation, and Evaluation. The resulting product combines geometric concepts with architectural elements of the Sade Traditional House, making learning more contextual, meaningful, applicable, and relevant to the students' cultural environment. Validation results show that the teaching module achieved a score of 88%, falling into the "highly valid" category, and is therefore suitable for use based on its content, presentation, language, graphics, appropriateness of the STEM approach, and integration of Indigenous Knowledge. In addition, the module also met the practicality criteria, with a student response rate of 86.18% (rounded to 86%), which falls into the "highly practical" category. This indicates that the module is easy to use, engaging, helps students understand the material, and supports student engagement in the learning process.

The teaching module developed was also proven effective in improving students' mathematical problem-solving skills. This was demonstrated by an increase in the average score of the experimental class from 33.76 on the pretest to 74.85 on the posttest, while the control class's score increased only from 36.89 to 41.63. The results of the Independent Samples t-Test showed a t-value of 9.356 with Sig. (2-tailed) < 0.001, indicating a significant difference in students' problem-solving skills between the experimental and control classes after the intervention was administered. Thus, the STEM-based teaching module integrated with Indigenous Knowledge of the Sade Traditional House meets the three main criteria for the quality of educational products: validity, practicality, and effectiveness. This module is suitable for use as an alternative geometry teaching material in high school because it not only improves students' problem-solving skills but also provides contextual, innovative, and locally-based mathematics learning that aligns with 21st-century learning demands.

RECOMMENDATION

Based on research findings indicating that the Science, Technology, Engineering, and Mathematics (STEM)-based teaching module—which integrates Indigenous Knowledge of the Sade Traditional House—meets the criteria of being valid, practical, and effective in enhancing students' problem-solving skills, this module is recommended for use as an alternative teaching resource in high school geometry instruction. Teachers are encouraged to implement this module in the learning process to create a more contextual, innovative, and student-centered learning experience. In addition, schools are expected to provide support by supplying resources, training, and guidance to teachers in developing STEM-based teaching materials that integrate the potential of local wisdom. The development of teaching materials that utilize local culture not only contributes to improving students' problem-solving skills but also strengthens the preservation of local culture and fosters students' appreciation for the cultural values present in their environment.

For future researchers, it is recommended to develop STEM-based teaching modules that integrate Indigenous Knowledge into mathematics and other subjects with a broader scope, involve a larger sample size, and implement them across various educational levels and school types so that the research findings have a higher degree of generalizability. Future research could also examine the impact of using these modules on other skills, such as critical thinking, creativity, mathematical literacy, communication, and collaboration, and conduct more comprehensive statistical analyses—such as N-gain, effect size (Cohen's d), or ANCOVA—to provide a deeper understanding of the modules' effectiveness. Thus, the development of STEM-based instructional materials integrated with Indigenous Knowledge is expected to become a sustainable learning innovation that enhances the quality of mathematics education while supporting the strengthening of 21st-century competencies and the preservation of local wisdom.

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AUTHOR CONTRIBUTIONS STATEMENT

Name of Author	C	M	So	Va	Fo	I	R	D	O	E	Vi	Su	P	Fu
Rasyidin	√	√	√	√	√	√		√	√	√			√	√
I Ketut Sukarma		√	√					√	√		√			
Akhmad Sukri				√			√			√				
Sutarto					√		√			√		√		

CONFLICT OF INTEREST STATEMENT

The authors declare no conflict of interest.

INFORMED CONSENT

We have obtained informed consent from all individuals included in this study.

DATA AVAILABILITY

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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