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Development of a creative geometry module: A reflective thinking–based problem-solving approach for fifth-grade students

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ABSTRACT

Elementary mathematics education continues to face challenges, particularly in developing higher-order thinking skills such as reflective thinking and mathematical problem solving. Traditional teaching methods that rely on direct instruction often limit students' opportunities to explore, question, and reflect, leading to difficulties in understanding abstract topics such as geometry. These limitations reduce students' conceptual understanding and their ability to connect mathematical ideas to real-life contexts. To address this issue, this study developed and evaluated a Creative Geometry Module that integrates problem-solving strategies with reflective thinking supports to improve conceptual understanding among fifth-grade students. The module was designed based on problem-solving principles and included guiding reflective questions, contextual examples, and structured learning activities. A preliminary trial was conducted with 30 students, followed by an experimental study with 60 students. Data were collected through observation sheets, student questionnaires, teacher reflective notes, and pre- and post-tests on geometry concepts. The results showed significant improvement in students' understanding of plane and solid shapes, with most students achieving high or very high learning gains. Observations also indicated that the module increased classroom engagement, supported reflective thinking, and encouraged collaborative problem solving. Teacher reflections confirmed the practicality and relevance of the module, although some challenges related to the time required for reflection were reported.

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1. Introduction

Mathematics education in elementary schools faces persistent challenges, particularly in fostering higher-order thinking skills such as reflective thinking and mathematical problem-solving. These skills are crucial in building a solid foundation for understanding more complex mathematical concepts. However, conventional teaching approaches continue to dominate classroom practice, with teachers often relying on direct instruction rather than encouraging students to explore, question, and solve problems independently (Noviani et al., 2025; Syamsuddin et al., 2023; Syamsuddin, 2019). This limited engagement restricts opportunities for reflective thinking, hindering students' ability to reason, argue, and internalize their understanding. Given the foundational role of mathematics at the elementary level, these shortcomings pose a significant concern for future learning (Syamsuddin et al., 2020).

Among the various domains of mathematics, geometry is one of the most demanding for elementary students. As a central branch of mathematics, geometry requires not only mastery of fundamental concepts but also the ability to apply these concepts in contextual situations (Syamsuddin et al., 2020). In practice, many students encounter difficulties in learning geometry due to low levels of active participation, instructional methods that do not align with their cognitive development, and limited supporting resources. Teacher-centered practices further reduce opportunities for students to engage in independent problem-solving. These challenges underscore the need for innovative and effective approaches that make geometry learning more meaningful and accessible.

One such promising approach is problem-solving through reflective thinking. In contrast to conventional methods that emphasize rote memorization, this approach actively involves

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students in critical and reflective processes as they solve mathematical problems (Acar and Azaklı, 2023). As a result, students not only strengthen their conceptual understanding but also develop transferable skills in reasoning, evaluating strategies, and problem-solving.

A preliminary study conducted at SD Panyikkokang I, Makassar, on September 23, 2023, revealed ongoing learning difficulties among fifth-grade students in geometry. The results from the second semester of the 2022/2023 academic year showed that many students scored below the Minimum Mastery Criterion (KKM = 75), with scores ranging from 71.20 to 74.80. Only a small number of students achieved scores slightly above the KKM, such as 75.20, 75.60, 76.40, and 77.60. These findings indicate that most students had not yet achieved satisfactory mastery of geometry.

Further analysis pointed to low visual ability as a key factor contributing to students' struggles, particularly in distinguishing between plane diagonals and space diagonals. Such difficulties often resulted in misconceptions and errors that hindered overall comprehension. Supporting evidence from prior studies shows that problem-solving approaches integrating visual representation and creative reasoning can enhance student understanding, particularly when tailored to individual cognitive styles (Mohamad and Tasir, 2023; Syamsuddin et al., 2021). Moreover, feedback in the form of guiding questions has proven effective in cultivating reflective thinking. Studies using association rule mining techniques confirmed a strong relationship between the types of questions posed and students' reflective responses during problem-solving (Olugbade et al., 2020).

In response to these challenges, there is a pressing need to develop a mathematics module that integrates problem-solving with reflective thinking. Such a module is expected to create a supportive and engaging learning environment that enhances reflective capacities while deepening conceptual and practical understanding of geometry. Consequently, this study seeks to answer the following research question: What are the outcomes of developing a mathematics module with a problem-solving approach to foster reflective thinking among fifth-grade elementary students on the topic of three-dimensional geometry? The objective is to design and validate such a module as an innovative solution to improve the quality of mathematics education at the elementary level.

Previous research has examined problem-solving approaches, reflective thinking, or geometry instruction separately. However, few studies have integrated all three into a contextual, reflective, and thematic learning module specifically tailored for elementary students. Furthermore, the application of reflective thinking in geometry learning at this level has not been widely tested, either theoretically or empirically. The originality of this study lies in the development and validation of a Creative Geometry Module that not only strengthens conceptual understanding but also systematically cultivates reflective thinking skills among elementary school students.

2. Research methodology

2.1. Research design

This study adopts a Research and Development (R&D) approach with the primary aim of producing a mathematics learning module based on a problem-solving approach integrated with reflective thinking to enhance students' understanding of geometry concepts in Grade V elementary school. The development model employed is the 4-D model, which consists of four stages: define, design, develop, and disseminate. The stages of the 4-D model applied in this study are presented in Fig. 1, which illustrates the process of developing and evaluating the Creative Geometry Module.

The implementation of this research focused on the application stage of the Creative Geometry Module in Grade V. The module had been developed and validated by subject matter experts and learning experts and was then implemented on a limited scale in two trial classes with a total of 30 students. The instruments used included.

Identifying the difficulties experienced by fifth-grade students in understanding geometry, particularly in the topics of two-dimensional and three-dimensional shapes, as presented in the explanation in Table 1. The findings regarding teachers' needs for teaching materials that support students' reflective thinking skills are summarized in Table 2.

The development of the Creative Geometry Module was carried out systematically to ensure that the learning content aligned with both the identified difficulties of students and the instructional needs of teachers. The process emphasized contextual problem-solving activities, reflective thinking prompts, and the use of visual representations to facilitate understanding of abstract concepts. Each component of the module, ranging from learning objectives, concept maps, and problem-solving steps to reflection sheets and authentic assessments, was designed to foster critical and reflective engagement, while remaining accessible through clear language and relevant examples drawn from students' daily experiences. The following Content Development of creative geometric models is presented in the explanation in Table 3.

The development of contextual problems in the Creative Geometry Module is designed to connect abstract mathematical concepts with students' real-life experiences. Each problem is carefully selected to represent situations familiar to fifth-grade learners, such as tiling a classroom floor, fencing a garden, or filling an aquarium. To support comprehension, the problems are accompanied by visual aids and simple illustrations that help students bridge the gap between two-dimensional representations and three-dimensional objects.

Furthermore, reflective questions are integrated at the end of each task to encourage students not only to solve the problems but also to evaluate their strategies, explore alternative solutions, and internalize their reasoning process as presented in the explanation in Table 4.

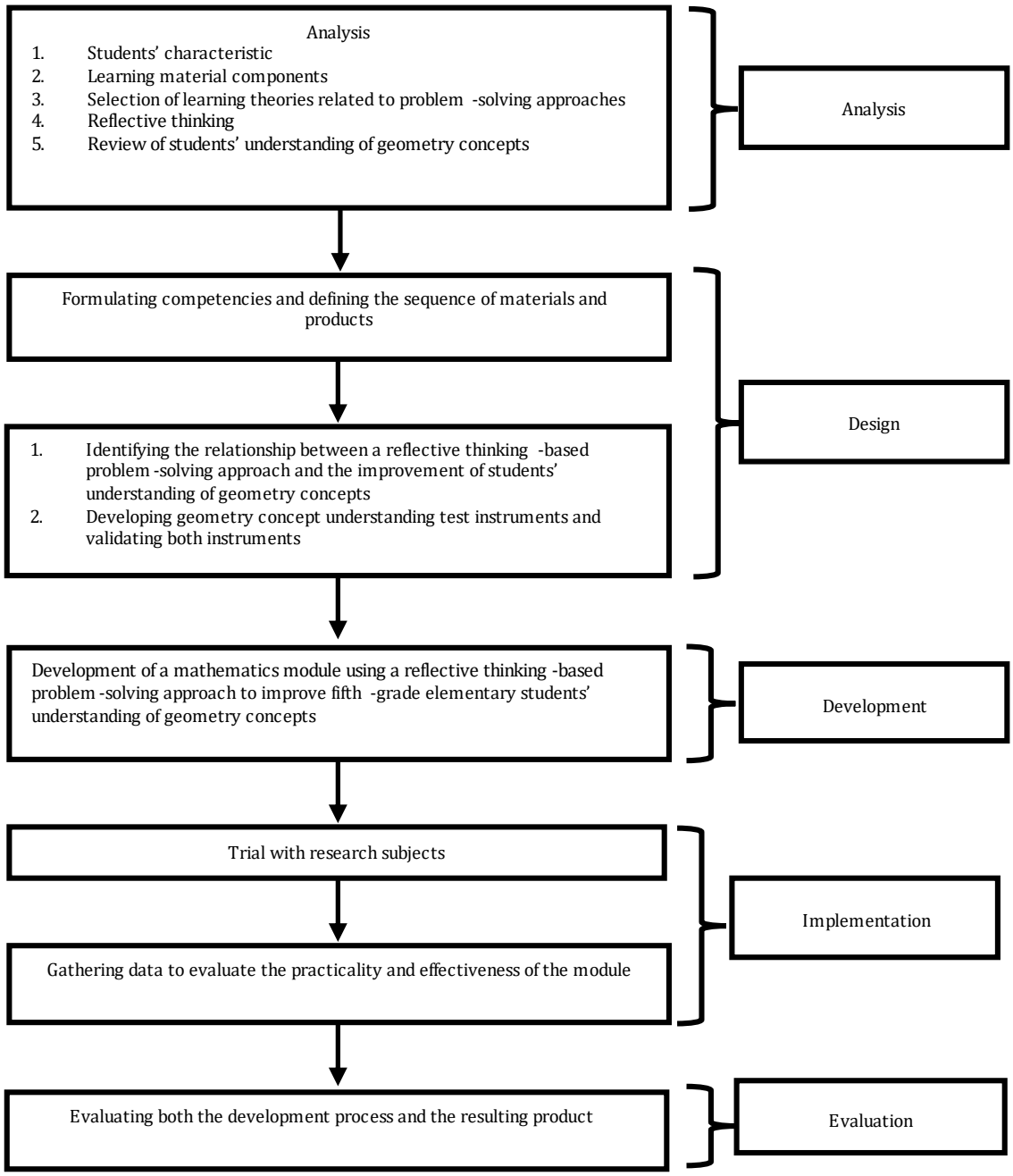


Fig. 1: The 4-D model

Table 1: The module design is based on the initial learning conditions

Aspect	Difficulty	Students needs	Module design
Conceptual understanding	Students struggle to understand the definitions and properties of 2D and 3D shapes.	Unable to mention the properties of an isosceles triangle or the difference between a cuboid and a cube.	Requires emphasis on introducing properties using teaching aids or visual illustrations.
Visualization and representation	Difficulty in visualizing geometric shapes when moving from two-dimensional to three-dimensional representations.	Confused in distinguishing between correct and incorrect cuboid nets.	Requires manipulative exercises with concrete models (folded paper, cubes/frames).
Connection between real–abstract concepts	Inability to relate everyday objects to abstract geometric figures.	Do not realize that a milk box is a cuboid or that a plate is circular.	Requires contextual problems closely related to students' daily life.
Problem solving	Difficulty applying area/volume formulas in word problems.	Confused when calculating the classroom floor area or the volume of an aquarium using given data.	Requires gradual practice with contextual problems, from simple to complex.
Mathematical language	Difficulty in understanding mathematical terms (sides, edges, diagonals, nets).	Refers to an edge as a "line" or the diagonal of a square as a "cross line."	Requires reinforcement of terminology with visual media, flashcards, and oral practice.
Reflective thinking	Rarely reviews the process of problem solving or evaluates their answers.	After calculating, students seldom check their results; incorrect answers are left uncorrected.	Requires guiding reflective questions ("Is there another way? Does your answer fit the context?").

Table 2: Teachers' needs for teaching materials that encourage students to actively engage in reflective thinking

Aspect	Teachers' needs	Statements	Module design
Contextual teaching materials	A module that contains problems and activities related to students' daily lives.	"Students understand more quickly when the problems use real objects, such as tiles, milk cartons, or cans."	The module includes contextual problems (e.g., calculating the area of classroom tiles, the volume of a milk box, etc.).
Problem-solving strategies	Step-by-step guidance to help students solve geometry problems systematically.	"Students need structured guidance, starting from understanding the problem to checking their answers."	The module presents problem-solving stages (understanding, planning, carrying out, reflecting).
Reflective thinking	Guiding questions to help students evaluate their answers and strategies.	"Students rarely review their work; they need to be directed with reflection questions."	The module provides a simple reflection sheet at the end of each activity (e.g., "Is this the easiest way?").
Media/visualization	Pictures, illustrations, or concrete models to support understanding abstract concepts.	"If it's only text, students get confused quickly. They need many pictures and visual examples."	The module is equipped with illustrations, nets, and visual steps to make concepts easier to understand.
Simple language	Learning materials and instructions are written in language that elementary students can easily understand.	"Instruction sentences should not be too long and should match children's language."	The module uses communicative language without reducing the accuracy of mathematical terminology.
Authentic assessment	Assessment instruments that evaluate the thinking process, not just final answers.	"There should be assessments that evaluate students' thinking processes, not only right or wrong answers."	The module includes a rubric for assessing reflective thinking (reasoning flow, justification, alternative solutions).

Table 3: Reflective thinking (guiding questions)

No	Topic	Problem	Reflective thinking (guiding questions)
1	Area of plane figures	Your classroom floor will be covered with square tiles, each with a side length of 40 cm. If the floor measures 8 m × 6 m, how many tiles are needed?	How did you calculate the number of tiles? Is there another, faster way?
2	Perimeter of plane figures	Aunt has a rectangular garden measuring 25 m by 15 m. She wants to build a fence around it. How many meters of fencing are required?	Did you count all the sides? What if the garden had a different shape, such as a triangle?
3	Volume of a cube	A cake box is in the shape of a cube with a side length of 20 cm. If each cake is a small cube with a side of 2 cm, how many cakes fit inside?	What is the relationship between the volume of the large box and the small cakes? How can you check your answer?
4	Volume of a cuboid	An aquarium is a cuboid with dimensions 50 cm × 30 cm × 40 cm. If it is filled with water to the top, how many liters of water are needed?	What is the relationship between cm^3 and liters? Can you visualize the volume of this aquarium?
5	Nets of a cuboid	The teacher brings a milk box shaped like a cuboid. If the box is unfolded into a net, what is the total area of the cardboard required?	How do you determine the faces of a cuboid? Have you included all the faces in your calculation?
6	Combination of plane figures	The schoolyard has a circular pond with a radius of 3 m, surrounded by a square-shaped pathway measuring 10 m × 10 m. What is the area of the pathway?	How do you separate the area of the pond from the area of the pathway? Is there another way to calculate the pathway's area?
7	Geometry in real life	A father wants to make a cardboard box in the shape of a cuboid with dimensions 60 cm × 40 cm × 30 cm. The box will be covered with wrapping paper. How much paper is needed?	Did you include all the surfaces of the box? How can you check if your answer is correct?

2.2. Research subjects and setting

The research subjects were 116 fifth-grade students selected randomly from an elementary school. A small-scale trial involving 30 students was first conducted to assess the initial validity and effectiveness of the developed module. Following this stage, a large-scale implementation was carried out using a quasi-experimental pretest–posttest control group design. The implementation involved four fifth-grade classes, consisting of two experimental classes (60 students) and two control classes (56 students). The experimental group was taught using the reflective-thinking-based geometry module, while the control group received instruction using conventional learning materials. The study was conducted in Makassar, Indonesia, during the 2023/2024 academic year.

2.3. Instruments for data collection

Four instruments were used to collect data in this study. Validation questionnaires were used to assess the content and design of the developed module. Content validation was conducted by experts in elementary mathematics education, while design validation was carried out by instructional technology experts and mathematics teachers. Both questionnaires used a Likert scale and included opportunities for qualitative feedback to support revisions to the module. Student and teacher response questionnaires were administered after the implementation of the module to evaluate its practicality, clarity, and usefulness. They included closed-ended Likert-type items and open-ended questions to obtain additional feedback. Observation sheets were used to monitor teacher and student activities during the implementation process. They recorded the extent to which the teaching activities followed the planned lesson scenarios and the level of student engagement in reflective thinking tasks. A geometry conceptual understanding test was also developed to assess students' understanding of geometry, particularly three-dimensional shapes. The test consisted of open-ended essay questions designed to measure higher-order cognitive skills at levels C4–C6 of Bloom's taxonomy. A minimum mastery criterion (KKM) of 75 was applied to determine whether students had achieved the required level of mastery. Students' scores were classified into five categories: very low (0–49), low (50–69), moderate (70–79), high (80–89), and very high (90–100).

2.4. Data analysis

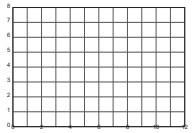
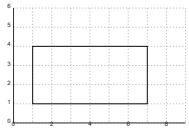
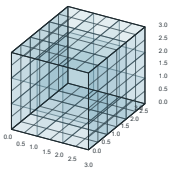
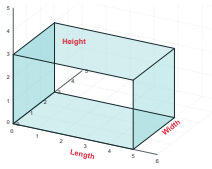
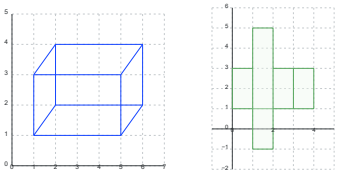
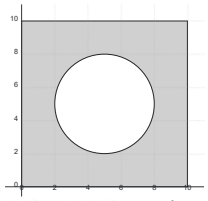
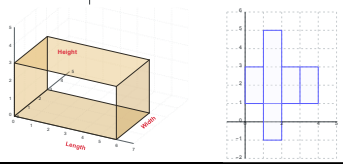
Descriptive statistics were used to analyze the expert validation scores, student response questionnaire results, and learning outcome test scores. Comparative analysis was conducted using pre-test and post-test scores from the experimental and control groups. Paired-samples t-tests were used to examine improvements in reflective thinking skills and learning outcomes. In addition, qualitative

data obtained from teacher reflections and student feedback were coded and analyzed thematically to support the refinement of the module.

3. Results

The module was implemented with a small group of fifth-grade students to examine the feasibility of the lessons, the level of student engagement, and their responses. After the developed instrument was distributed and reviewed by the validators, a revision is presented in the following explanation. The revisions made to the Creative Geometry Module based on the validators' suggestions and evaluation results are presented in Table 5.

Table 4: Creative geometry module design

No	Topic	Contextual problem	Visualization	Reflective questions
1	Area of a square	A classroom floor measuring 8 m × 6 m will be covered with square tiles, each with a side length of 40 cm. How many tiles are needed?		How did you calculate the number of tiles? Is there another faster way?
2	Perimeter of a rectangle	Aunt's garden is rectangular, measuring 25 m in length and 15 m in width. She wants to install a fence around the garden. How many meters of fencing are required?		Did you count all the sides? What if the garden had a different shape, such as a triangle?
3	Volume of a cube	A cake box is in the shape of a cube with a side length of 20 cm. Each cake is a small cube with a side length of 2 cm. How many cakes can fit inside the box?		What is the relationship between the volume of the large box and the small cakes? How can you check your answer?
4	Volume of a cuboid	An aquarium has the shape of a cuboid with dimensions 50 × 30 × 40 cm. If filled to the top, how many liters of water are needed?		What is the relationship between cm^3 and liters? Can you visualize the volume of this aquarium?
5	Nets of a cuboid	A milk carton in the shape of a cuboid is unfolded into a net. What is the total area of the cardboard required to make it?		How do you determine the faces of the cuboid? Have you counted all the faces of the cuboid?
6	Combination of plane figures	The schoolyard has a circular pond with a radius of 3 m in the middle of a square pathway measuring 10 m × 10 m. What is the area of the pathway around the pond?		How do you separate the area of the pond from the area of the pathway? Is there another way to calculate the pathway area?
7	Surface area of a cuboid	A cardboard box in the shape of a cuboid with dimensions 60 × 40 × 30 cm will be covered with wrapping paper. How much paper is needed?		Did you count all the surfaces of the box? How can you check if your answer is correct?

The observation sheet was used to assess the extent to which the implementation of the module was carried out in accordance with the lesson plan. Observations were conducted by two observers (a partner teacher and the researcher) over three trial sessions with a total of 30 students. The observation instrument included four components: introduction, core activities, reflective thinking, and closure, as presented in the explanation in Table 6.

The limited trial implementation of the Creative Geometry Module: A Reflective Thinking-Based Problem-Solving Approach aimed to ensure the feasibility of the learning process, assess student responses, and identify the strengths and weaknesses of the module before proceeding to a broader application. This trial involved 30 fifth-grade students from an elementary school and was conducted over three meetings, each lasting 2 × 35 minutes.

As part of the evaluation of the limited trial, the researchers also collected reflective notes from four teachers involved in the implementation of the module. These notes served to capture how the module facilitated teaching, its effectiveness for students, and which aspects needed refinement for the next stage of implementation. Overall, the reflections indicated that the module was practical, contextual, and helpful in encouraging students to

think more critically. However, some challenges remained, particularly in habituating students to write reflections and in simplifying problem instructions. The reflective notes provided by the teachers during the limited trial are summarized in Table 7.

Table 5: Revisions of the creative geometry module

No	Aspect	Findings/problems	Improvements made	Evidence of revision (before → after)
1	Language/wording	Instructional sentences were too long and difficult for students to understand.	Simplified sentences to be more concise and communicative, appropriate for the elementary level.	Before: "State the properties of a rectangle that you know from the picture below by writing them completely." → After: "Write the properties of the rectangle from the following picture!"
2	Illustrations and images	Black-and-white images were less engaging and lacked contextual relevance.	Added colored and contextual illustrations (tiles, milk cartons, aquariums, boxes, etc.).	Before: plain cube image. → After: colored cube-shaped milk carton illustration.
3	Contextual problems	Some problems were not sufficiently connected to students' real-life experiences.	Replaced or added problems with contexts more familiar to daily student life.	Before: "Calculate the area of a trapezoidal garden with side lengths …" → After: "Calculate the area of the school yard in the shape of a square with a side length of 20 m."
4	Reflective questions	Students wrote only brief reflections and were not accustomed to giving logical reasons.	Added varied reflective questions, ranging from simple to progressively challenging.	Before: "Is your answer correct?" → After: "Is there another way to solve this problem? Why did you choose your previous method?"
5	Learning time	Reflection stage was often rushed due to limited time.	Allocated dedicated time for reflective discussions at the end of the lesson.	Before: reflection lasted only 5 minutes. → After: reflection extended to 10–15 minutes at the end of the session.
6	Activity instructions	Activity instructions were too general and not sequential.	Clarified instructions using systematic steps (observe – calculate – discuss – write).	Before: "Calculate the area of the following shape." → After: "1) Observe the shape. 2) Write down the known data. 3) Calculate the area. 4) Discuss your result with a friend."
7	Evaluation/tests	Tests focused only on final answers, without assessing the thinking process.	Added process-based assessment rubrics (reasoning, steps, alternative solutions).	Before: assessed only the numerical result. → After: assessed final answer + strategy + students' reflective reasoning.

Table 6: Observation results

Learning stage	Observed indicators	Implementation percentage	Category	Observers' notes
Introduction	The teacher opened the lesson with an introduction (apperception) and conveyed the learning objectives.	85%	Very good	The introduction was engaging; students were enthusiastic when linked to real objects (tiles, boxes).
Core activities	– Presentation of contextual problems – Group discussion – Problem-solving strategies	80%	Good	Some students still struggled to write down their strategies in a systematic manner.
Reflective thinking	The teacher provided reflective questions; students reviewed their solutions and wrote reflections.	78%	Good	Students began to get used to reviewing their answers, though some responses were still brief.
Closure	The teacher and students concluded the lesson, provided reinforcement, and outlined follow-up activities.	84%	Very good	The concluding discussion went well; students were confident in presenting their answers in front of the class.

Table 7: Teachers' reflective notes

Teacher	Positive aspects	Challenges encountered	Reflection and follow-up plan
Mathematics teacher, class VA	Students found it easier to understand concepts with the use of pictures and real objects.	Some students were still confused about writing the steps of problem-solving.	Will habituate students to gradually write down strategies using simple examples.
Mathematics teacher, class VB	Reflective questions helped students think more critically and not only focus on answers.	Lesson time felt insufficient for the reflection stage.	Will allocate specific time at the end of each session for student reflection discussions.
Mathematics teacher, class IVA	The module was practical to use because instructions were clear and systematic.	Some problem statements were too long and difficult for students to understand.	Will simplify problem sentences to make them more appropriate for elementary students' language.
Mathematics teacher, class IVB	Contextual activities (tiles, boxes, aquarium) made students enthusiastic about learning.	Some students only gave brief reflective answers without logical reasoning.	Will provide more varied reflective questions that are simpler yet encourage deeper responses.

After implementing the Creative Geometry Module in Grade V, teachers observed positive changes in how students understood geometry concepts. The use of contextual problems drawn from everyday life, such as calculating the area of floor tiles, the volume of an aquarium, or recognizing the shape of a box, made students more enthusiastic and quicker to grasp the meaning of the tasks. However, teachers also noted that some students still struggled to write their problem-solving strategies in a systematic and clear manner. This indicates that reflective practice needs to be gradually reinforced so that students become accustomed to evaluating their own thinking processes. Overall, the teachers considered the module effective in increasing student engagement and providing a more meaningful alternative to traditional mathematics learning. In the core activities, the teacher presented contextual problems related to plane and solid figures. Students were divided into small groups to analyze the problems, formulate strategies, and collaboratively solve the tasks. During the discussions, the teacher posed guiding reflective questions such as "Why did you choose this method?" or "Is there another strategy that could be used?" These questions encouraged students to revisit their thinking processes, ensuring that they were not merely focused on obtaining the final answer but were also developing critical and reflective thinking skills.

3.1. Implementation data for small groups

As part of the trial evaluation, students were then asked to complete a short test designed to assess both their conceptual understanding of geometry and their ability to apply problem-solving strategies. This test also served as an important instrument for examining the effectiveness of the module in enhancing students' learning outcomes. During the implementation stage, students worked in small groups or pairs according to the classroom arrangement. They appeared attentive to the teacher's instructions and focused on completing the geometry test provided. Each student received a worksheet containing contextual problems related to plane and solid figures. The classroom atmosphere was calm, with most students concentrating on writing their answers, while some engaged in light discussions to better understand the problems. The teacher and the researcher acted as observers to ensure that the learning process followed the scenarios outlined in the module. The teacher guided the students with clear instructions, while the researcher recorded the implementation process using observation sheets. Furthermore, interactions among students indicated that the module successfully encouraged them to think critically, collaborate with peers, and practice reflective thinking through guiding questions. Documentation of the activities showed the students' enthusiasm in completing the test.

Some students helped one another in understanding the questions, while others worked individually with strong concentration. These observations suggest that the module can serve as a contextual learning resource while simultaneously fostering reflective thinking skills among fifth-grade students. The results of the limited trial are summarized as presented in the explanation in Table 8.

Table 8: Improvement categories

Category	Range of score improvement	Number of students	Percentage
Very high	≥ 25 points	5 students	16.7%
High	15 – 24 points	12 students	40.0%
Moderate	5 – 14 points	9 students	30.0%
Low	< 5 points	4 students	13.3%
Total	–	30 students	100%

Based on the student improvement table from the limited trial, it can be explained that student learning outcomes after using the Creative Geometry Module: A Reflective Thinking-Based Problem-Solving Approach showed positive progress. Of the 30 students who participated in the trial, the majority (40%) were in the highest improvement category. This indicates that nearly half of the students experienced significant gains in understanding geometry using the module.

Furthermore, 30% of students fell into the moderate improvement category, suggesting that they were able to follow the learning flow effectively, although they still required guidance in certain areas, particularly when articulating problem-solving strategies. Meanwhile, 16.7% of students achieved a very high improvement category, demonstrating that some were able to adapt quickly, develop a deep conceptual understanding, and consistently reflect on their thinking processes. On the other hand, 13.3% of students were in the low improvement category. This group generally faced difficulties in writing reflections and in connecting abstract concepts with real-life objects. This finding serves as an important note for further refinement of the module as well as for strengthening teacher support strategies in subsequent large-scale implementations.

3.2. Student responses to the creative geometry module

The administration of the student response questionnaire for the Creative Geometry Module: A Reflective Thinking-Based Problem-Solving Approach was conducted after the entire series of learning activities in the limited trial had been completed. The questionnaire was distributed to 30 fifth-grade students using a 4-point Likert scale. It contained statements related to the clarity of language, the usefulness of images and illustrations, the contextual relevance of problems to daily life, the presence of reflective questions, and the motivation to learn mathematics.

By completing the questionnaire, students were asked to provide evaluations based on their experiences using the module, allowing the researchers to gain insights into its readability, attractiveness, and effectiveness in supporting both conceptual understanding of geometry and the habituation of reflective thinking, as presented in the explanation in Table 9.

Table 9: Student response questionnaire results

No	Statement	Average score	Percentage	Category
1	The language in this module is easy to understand.	3.4	85%	Very good
2	The pictures and illustrations in the module help me understand geometry concepts.	3.5	87.5%	Very good
3	The problems in the module are related to my daily life (tiles, cardboard boxes, aquariums, etc.).	3.3	82.5%	Good
4	The reflective questions in the module help me review my way of thinking.	3.2	80%	Good
5	The module makes me more enthusiastic about learning geometry.	3.4	85%	Very good
6	The module helps me work together with friends during group discussions.	3.3	82.5%	Good
7	I find it easier to solve geometry word problems after using this module.	3.2	80%	Good
8	I enjoy learning with this module.	3.5	87.5%	Very good

The implementation of the experimental group was carried out after the limited trial stage, involving 60 fifth-grade students as participants. The Creative Geometry Module: A Reflective Thinking-Based Problem-Solving Approach was applied to this group to evaluate its effectiveness on a larger scale. The classroom teacher acted as the primary facilitator, while the research team observed the learning process, documented student engagement, and collected data on learning outcomes. The activities included contextual problem-solving tasks, group discussions, and reflective questioning, all of which were designed to strengthen students' conceptual understanding of geometry and foster reflective thinking.

The implementation results from the experimental group served as the basis for assessing the module's validity, practicality, and effectiveness before preparing for broader dissemination. Next, a test was conducted in 2 groups, namely the experimental class and the control class. This is presented in the following Table 10.

Table 10: Improvement categories (experimental group)

Category	Range of score improvement	Number of students	Percentage
Very high	≥ 25 points	10 students	16.7%
High	15 – 24 points	24 students	40.0%
Moderate	5 – 14 points	18 students	30.0%
Low	< 5 points	8 students	13.3%
Total	–	60 students	100%

Based on the improvement data of 60 fifth-grade students in the experimental group, it was found that the majority (40%) were in the great improvement category, while 30% achieved moderate improvement. A total of 16.7% of students were categorized as very high, showing outstanding progress, whereas 13.3% fell into the low improvement category, as presented in the explanation in Table 11.

Table 11: Improvement categories (control group)

Category	Range of score improvement	Number of students	Percentage
Very high	≥ 25 points	3 students	5.4%
High	15 – 24 points	7 students	12.5%
Moderate	5 – 14 points	36 students	64.3%
Low	< 5 points	10 students	17.9%
Total	–	56 students	100%

The findings show that most students in the control group (64.3%) were in the moderate improvement category, indicating a modest level of learning progress. A smaller proportion of students achieved high and very high improvement levels, while only 17.9% remained in the low improvement category. To prove the effectiveness of the creative geometry module development, a paired-samples t-test was conducted as shown in Table 12.

Table 12: Paired samples correlation

Pair	Variables	N	Correlation	Sig.
1	Pre_EKS and Post_EKS	60	0.223	0.262
2	Pre_CTR and Post_CTR	56	0.513	0.049

The findings indicate that there is no significant relationship between pre-test and post-test scores in the experimental group, suggesting that students' final performance was not dependent on their initial ability. This implies that the learning intervention influenced students' achievement more dynamically. In contrast, the control group shows a significant positive relationship between pre-test and post-test scores, indicating that students' initial ability tended to be consistently reflected in their final learning outcomes under conventional instruction, as presented in the explanation in Table 12.

The results of the paired samples t-test showed that there is a significant difference between the pre-test and post-test scores in both the experimental group and the control group. These findings confirm that the learning activities in both groups resulted in measurable improvements in student learning outcomes. However, the increase observed in the experimental group reflects the effectiveness of the reflective thinking-based learning module in achieving stronger learning outcomes compared to conventional learning, as presented in the explanation in Table 13.

Table 13: Paired samples t-test

Pair	Variables	Mean difference	Std. deviation	Std. error mean	t	df	Sig. (2-tailed)
1	Pre_EKS – Post_EKS	-22.40	7.90	1.02	-21.98	59	0.001
2	Pre_CTR – Post_CTR	-18.61	5.10	0.68	-27.30	55	0.001

The results of the effect size analysis (Table 14) show that the creative geometry module has a very strong impact on improving students' abilities, both in the aspects of ECS (Exploration of Spatial Concepts) and CTR (Creative Thinking and Reasoning). The high effect size indicates that the creative geometry module is not only effective but also has a significant impact on students' abilities. The increase that occurs (≥ 0.8) shows that this module is capable of drastically transforming learning outcomes through an innovative, contextual, and meaningful approach.

3.3. Reflective thinking results

Reflective thinking refers to students' ability to consciously understand a problem, plan an appropriate strategy, monitor their thinking process,

evaluate the results, and draw meaningful conclusions from their learning activities. This ability plays an important role in helping students become more aware of how they learn, recognize their strengths and weaknesses, and improve their problem-solving performance. The distribution of students' reflective thinking skills based on each indicator is presented in Table 15. The distribution of students' reflective thinking skills shows that most students demonstrated strong performance across all indicators. The highest achievement was found in problem recognition, while the lowest was observed in monitoring the thinking process. Overall, these results indicate that students' reflective thinking abilities developed well after the learning intervention

Table 14: Paired samples effect sizes

Pair	Comparison	Standardizer	Point estimate	95% CI lower	95% CI upper
1	Pre_EKS – Post_EKS	Cohen's d	7.89593	-3.404	-2.264
		Hedges' correction	7.94657	-3.382	-2.250
2	Pre_CTR – Post_CTR	Cohen's d	5.10144	-4.373	-2.916
		Hedges' correction	5.13655	-4.343	-2.896

Table 15: Reflective thinking results

No	Reflective thinking indicator	Frequency	Percentage
1	Recognizing the problem	49 students	81.7%
2	Planning the strategy	46 students	76.7%
3	Monitoring the process	43 students	71.7%
4	Evaluating the result	45 students	75.0%
5	Drawing conclusions	47 students	78.3%

4. Discussion

The implementation of the Creative Geometry Module in the experimental class demonstrated that the instructional phase's introduction, core activities, reflective thinking, and closure were carried out according to the lesson design. After the implementation of the creative geometry module and the subsequent posttest given to both the experimental and control groups, it was found that the application of the creative geometry module significantly impacted the improvement of students' reflective thinking and problem-solving abilities. This is evident from the distribution of score increases in the experimental group, where most students experienced development in the high to very high category, far better than the control group. Observations during the learning process also indicated several important indicators that explain the effectiveness of the module in enhancing students' higher-order thinking skills.

First, the exploratory nature of the geometry activities in the module encourages students to think reflectively. The module presents visual, manipulative, and context-based activities that allow students to review their problem-solving steps, evaluate the strategies they chose, and compare various alternative solutions. Such activities strengthen the cycle of reflective thinking, as students focus not only on obtaining the final answer but also on understanding the reasons and concepts underlying each step. Second, the integration of visual representations in the module significantly enhances conceptual understanding. Geometry, being a highly visual field, requires illustrations, interactive diagrams, and visual-spatial models for students to grasp the relationships between concepts more profoundly. Through these comprehensive and engaging representations, students find it easier to identify patterns, connect concepts, and construct systematic solutions. A stronger understanding of geometric structures directly contributes to the enhancement of their problem-solving abilities. Third, the presentation of contextual problems in the module stimulates higher-order reasoning. The tasks not only emphasize mathematical procedures but also invite students to analyze situations, interpret information, and make appropriate mathematical decisions. Thus, the module helps students develop critical and creative thinking skills, which are two key components in problem-solving.

Fourth, the module is designed with a scaffolding structure that allows students to learn independently and reflect on their thinking processes. Students are given the space to test their understanding, correct mistakes through self-feedback, and reassess the steps they take. This approach has proven effective in enhancing reflective thinking, as students are consistently encouraged to evaluate their own thinking methods. Fifth, the creative learning environment through the module significantly increases student motivation and engagement. Activities such as shape construction, pattern exploration, and small projects make learning more interesting and meaningful. These creative elements foster curiosity, enhance intrinsic motivation, and encourage students' cognitive engagement. When students are actively involved and interested in the learning process, their problem-solving abilities develop faster and stronger. The creative geometry module is not only effective in enhancing conceptual knowledge but also plays a crucial role in shaping reflective mindsets and students' problem-solving skills. This makes the module an innovative and impactful learning tool in geometry education.

In contrast, improvements in the control class indicate that without the use of the creative geometry module, the enhancement of students' reflective thinking and problem-solving abilities is at a much lower level compared to the experimental group. This underscores that conventional learning approaches commonly used in classrooms are not optimally promoting the development of higher-order thinking skills. The lack of supporting media, limited variation in teaching strategies, and absence of reflective activities have resulted in students being less encouraged to develop analytical and evaluative thinking. One of the main causes of the

low improvement in student abilities is that learning tends to focus solely on procedures rather than on the reflective thinking process. Without a creatively and exploratively designed module, learning activities are more centered on solving problems mechanically, oriented towards final answers, and offer minimal opportunities for discussion or error analysis. As a result, students complete problems mechanically without evaluating the strategies used, leading to a slow development of reflective thinking skills.

Additionally, the minimal visual representation in conventional learning leads to a shallow understanding of geometry concepts among students. Geometry, as a highly visual field, requires illustrations, diagrams, and spatial models to help students visualize the relationships between objects. Without such support, students tend to memorize formulas without understanding the mathematical context underlying them. As a result, their problem-solving abilities are low because they cannot connect concepts to devising solution strategies. The absence of systematic scaffolding is also a hindering factor. In the control class, students often work without reflective guidance; the learning process is linear and moves directly to exercises, and there is no space for students to test and review the methods they use. Without a supportive structure to help build gradual strategies, students tend to revert to the same methods and do not develop a diversity of approaches to problem-solving.

Furthermore, conventional learning lacks the stimulation of students' creativity and curiosity. The absence of creative activities such as exploring shapes, creating visual models, or engaging in contextual tasks makes students less deeply involved. Learning activities become routine, intrinsic motivation is low, and cognitive interaction is limited. This condition leads to minimal improvement in reflective thinking and problem-solving skills. Students in the control group are not accustomed to self-evaluation. The lack of reflective questions, self-evaluation sheets, or activities to review solution steps means students rarely ask critical questions like “Why did I choose this step?” or “Is there a more efficient way?” This lack of reflective habits slows the development of reflective thinking and leads to uneven improvement. The low achievement of the control group indicates that without the support of creative geometry modules, learning fails to provide deep, structured, and reflective thinking experiences, preventing students' problem-solving and reflective thinking abilities from developing optimally.

Moreover, the correlation analysis results show that the creative geometry module influences the improvement of students' reflective thinking and problem-solving skills. The correlation between pre-test and post-test scores indicates that the changes in ability are significantly influenced by the quality of learning intervention provided through the module. In Pair 1, the correlation between Pre_Eks and Post_Eks is 0.223 with a significance of 0.262, indicating that the improvement in reflective thinking skills does not depend on students' initial abilities. This means that students with low, medium, or high initial abilities all experience increases after using the module. Contextually, this shows that the creative geometry module is designed inclusively by providing visual and conceptual scaffolding, facilitating step-by-step exploration, and helping students reflect on their thinking processes. Through activities that prompt students to revisit strategies, identify mistakes, and improve their thought processes, this module effectively provides opportunities for all students to develop reflective thinking without exception.

Meanwhile, in Pair 2, a correlation of 0.513 was found between Pre_CTR and Post_CTR with a significance of 0.049, indicating a significant moderate relationship between initial ability and the improvement in problem-solving skills. This means that students with a stronger foundation in mathematical reasoning can more quickly utilize the features of the module, such as concept visualization, contextual examples, and exploratory guidance. Nevertheless, students with low initial abilities still showed significant improvement because the module provides a gradual understanding of concepts, various representations of problem-solving, and reflective exercises that help them recognize misconceptions. Thus, the creative geometry module functions effectively as a booster that enhances students' abilities according to the foundations they possess.

The creative geometry module serves as the main driver of higher-order thinking activation in the learning process. The module not only presents material but also provides visual, exploratory, and reflective learning experiences. Students are not only asked to answer questions but are also directed to understand why and how a solution is obtained. The contextual problems in the module encourage students to analyze situations, evaluate strategies, and revise their problem-solving approaches, thus directly enhancing their reflective thinking and problem-solving abilities. Therefore, the small correlation in Pair 1 emphasizes that the improvement in reflective thinking is due to the quality of the module, not the students' initial abilities, while the moderate correlation in Pair 2 indicates that problem-solving develops more optimally in students who can utilize the structure of the module, although all students still gain significant benefits.

These results are reinforced by the achievement indicators in Table 15, where most students reached a high level of mastery across all components of reflective thinking, with achievement percentages ranging from 71.7% to 81.7%. The high percentage in the indicator "Recognizing the Problem" (81.7%) indicates that the module helps students understand the context of problems more clearly through illustrations, real-world contexts, and visual explanations of geometry. In the indicator "Planning the Strategy" (76.7%), the module provides

scaffolding for thinking steps, so students become accustomed to planning before solving problems. The ability "Monitoring the Process" (71.7%) is also developed because the module provides guiding questions that encourage students to review their steps. The high score in "Evaluating the Result" (75.0%) shows that students can assess the logical consistency of their solutions through activities of reviewing answers and checking procedural consistency. Finally, the indicator "Drawing Conclusions" (78.3%) indicates that the module successfully trains students' ability to summarize understanding, explain strategies, and interpret the learning processes they have undergone. Based on the overall findings, it is concluded that the creative geometry module not only enhances conceptual knowledge but also strengthens students' reflective thinking and problem-solving abilities through a systematically designed visual, contextual, exploratory, and reflective approach.

This finding aligns with research showing that problem-solving–based modules with clear structure enhance classroom feasibility (Deringöl, 2019). Studies on geometry modules have further emphasized that contextualized modular approaches support coherent implementation (Asri et al., 2024). Similarly, Susanto and Usman (2024) reported that problem-based instruction provides direction and coherence for students during learning. Additional evidence also suggests that feasibility is a critical aspect of validating classroom practice (Indrapangastuti et al., 2024). Furthermore, Angkotasan et al. (2024) highlighted that reflective scaffolding in modular learning fosters alignment between teaching plans and classroom realities. Collectively, these findings confirm that the module can be effectively adopted in real classroom contexts while facilitating teacher guidance.

Students' responses to the Creative Geometry Module revealed that most participants perceived the material as clear, attractive, and relevant to real-life situations. This result is consistent with a recent study on open problem-based geometry e-modules, which reported high validation scores and positive student feedback. In another context, Asri et al. (2024) found that contextualized geometry modules improved students' motivation and collaborative engagement in group discussions. Research on reflective thinking in mathematics further demonstrated that reflective tasks embedded in modules support students in internalizing strategies. Susanto and Usman (2024) also argued that students' engagement is strengthened when they perceive direct relevance between contextual problems and their lived experiences. Likewise, PBL-oriented geometry instruction was shown to improve both cognitive activity and learning commitment (Indrapangastuti et al., 2024). Deringöl (2019) similarly reported that well-designed problem-solving modules are positively received by students due to their clear guidance. These converging findings indicate that the module is not only technically practical but also pedagogically acceptable. One of the primary aims of the module was to foster reflective thinking through guiding questions embedded in each activity. Deringöl (2019) found that reflective thinking ability strongly correlates with achievement in mathematics and geometry. Angkotasan et al. (2024) highlighted that many students find reflective processes challenging, yet these can be cultivated with systematic scaffolding. Sujadi et al. (2025) observed that reflective thinking stages, often overlooked, significantly enhance students' metacognition when explicitly integrated into instruction. Teacher training research further suggests that reflective support contributes to improved evaluation of classroom practice (Su et al., 2025). Martin et al. (2023) similarly reported that reflective prompts help students visualize and articulate their strategies. Taken together, these studies indicate that reflective questioning within the module successfully stimulated students to revisit their reasoning processes and consider alternative strategies.

Post-test results indicated significant gains in students' conceptual understanding of geometry, particularly plane and solid figures. Susanto and Usman (2024) demonstrated that problem-based instruction strengthens reasoning skills in geometry. Indrapangastuti et al. (2024) found that PBL approaches improved spatial visualization and deductive reasoning. Asri et al. (2024) noted that contextualized tasks fostered stronger links between abstract ideas and tangible objects. Martin et al. (2023) showed that reflective prompts combined with visual scaffolds improved students' ability to represent geometric relationships. These findings affirm that visualization and illustration are indispensable in making abstract geometry more comprehensible, a conclusion consistent with outcomes observed in the current study.

Despite the overall success of the implementation, several challenges emerged, particularly regarding students' unfamiliarity with writing reflections and articulating problem-solving strategies sequentially. Angkotasan et al. (2024) similarly reported difficulties among students in sustaining reflective thinking during mathematical tasks. Aghakhani et al. (2023) argued that reflective practice in classrooms often encounters barriers related to time allocation and teacher support. Susanto and Usman (2024) observed that balancing problem difficulty with student ability remains a common challenge in problem-based geometry instruction. Siew and Basari (2024) noted that limited time for reflective discussions reduced the effectiveness of PBL in Malaysian classrooms. Indrapangastuti et al. (2024) found that high levels of scaffolding were required when students faced complex word problems in geometry. Ovadiya (2025) also indicated that systematic integration of reflective tasks is necessary to avoid their treatment as supplementary rather than core components of learning. These findings suggest that, although promising, careful attention to scaffolding and time

management is essential for wider implementation. The implementation results suggest that the Creative Geometry Module is a promising tool for enhancing conceptual understanding and reflective thinking in elementary mathematics. Arifin and Ardianto (2024) recommended further enrichment of modules with digital or AR-based media to improve engagement and learning outcomes. Su et al. (2025) argued that sustained reflective teaching practice among teachers is essential to ensure long-term instructional innovation. Susanto and Usman (2024) emphasized the importance of providing multiple solution strategies within modules to encourage flexible problem solving. Indrapangastuti et al. (2024) suggested reinforcing visual scaffolds to reduce cognitive load among novice learners. Asri et al. (2024) recommended expanding contextualized modules to larger populations to confirm scalability. Based on these insights, future studies should pilot larger-scale implementations, integrate digital interactivity, and assess long-term impacts on critical and reflective thinking.

5. Conclusions

The implementation of the Creative Geometry Module: A Reflective Thinking–Based Problem-Solving Approach for fifth-grade elementary students demonstrated promising results in enhancing both conceptual understanding of geometry and reflective thinking skills. The module was successfully validated and trialed, showing feasibility across instructional phases, from introduction to closure. Student responses indicated that the material was clear, engaging, and contextually relevant, while reflective prompts embedded in the module encouraged students to critically review and refine their reasoning processes. Post-test results confirmed significant improvements in conceptual mastery, especially in visualizing and solving problems involving plane and solid figures. Although challenges remained, particularly in students' unfamiliarity with writing reflections and limited time allocation for reflective tasks, overall findings affirm that the module is both practical for classroom implementation and effective in promoting meaningful mathematics learning.

6. Implications

The Creative Geometry Module can be adopted by teachers as a structured learning resource to support the transition from teacher-centered instruction to student-centered reflective learning. By incorporating contextual problems and reflective prompts, the module encourages students to develop higher-order thinking skills rather than rely solely on rote procedures. The challenges identified in the implementation, particularly students' difficulties in explaining their problem-solving strategies and the limited time available for reflection, highlight the importance of providing appropriate scaffolding. Teachers should gradually guide students in expressing their reasoning, allocate sufficient time for reflective discussions, and simplify task instructions where necessary. These strategies may help students better understand and internalize problem-solving processes. Future studies should examine the implementation of the module with larger student populations and in diverse educational contexts to further assess its scalability and sustainability. Integrating digital platforms, including interactive tools and augmented reality (AR), may also improve the visualization of geometric concepts and increase student engagement. Furthermore, longitudinal studies could investigate how the development of reflective thinking skills in elementary education influences students' learning progression in higher grades.

List of abbreviations

4-D	Four-dimensional development model
AR	Augmented reality
C4–C6	Cognitive levels 4–6 of Bloom's taxonomy
CI	Confidence interval
CTR	Creative thinking and reasoning
df	Degrees of freedom
ECS	Exploration of spatial concepts
KKM	Minimum mastery criterion
N	Sample size
PBL	Problem-based learning
Post_CTR	Post-test score for the control group
Post_EKS	Post-test score for the experimental group
Pre_CTR	Pre-test score for the control group
Pre_EKS	Pre-test score for the experimental group
R&D	Research and development
SD	Sekolah dasar (elementary school)
Sig.	Significance
Std.	Standard
t	t-statistic

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Compliance with ethical standards

Ethical considerations

Permission to conduct the research was obtained from the participating school. Informed consent was

obtained from the parents or legal guardians of the participating students, and the students provided age-appropriate assent before taking part in the study. Participation was voluntary, and the confidentiality and anonymity of the participants were maintained throughout the research.

Conflict of interest

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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