Students' Mathematical Representation in Geometry Problem-Solving: A Case Study on Fifth Class at SDN Brangkal 1

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Abstract
Elementary school students often rely on memorizing formulas to solve math problems without understanding the visual meaning of concepts, leading to difficulties in accurately representing ideas. This study aims to examine students' mathematical representation abilities in solving problems related to two-dimensional shapes. A qualitative case study approach was employed through interviews with a classroom teacher and ten students at SDN Brangkal 1. Data were analyzed using thematic coding. The findings indicate that most students still depend on formula memorization, rarely use drawings, fail to verify their answers, and struggle to explain the reasoning behind their problem-solving steps. Their verbal representation skills are also limited, as they tend to provide short answers without sufficient explanation and show little habit of expressing their thought processes. These results reveal that students' mathematical representation competence in geometry remains low. Therefore, it is necessary to implement learning strategies that integrate visual, symbolic, and verbal representations while fostering reflection and communication habits in elementary geometry education.
Keywords: *mathematical representation, geometry probem-solving, elementary school students, case study.*

Abstrak
Peserta didik sekolah dasar sering bergantung pada hafalan rumus dalam menyelesaikan soal matematika tanpa memahami makna visual konsep, sehingga kesulitan merepresentasikan ide secara tepat. Penelitian ini bertujuan menyelidiki kemampuan representasi matematis siswa dalam menyelesaikan masalah terkait bentuk bidang datar. Pendekatan kualitatif studi kasus digunakan dengan wawancara terhadap guru kelas dan sepuluh siswa SDN Brangkal 1. Data dianalisis menggunakan pengodean tematik. Hasil penelitian menunjukkan bahwa sebagian besar siswa masih mengandalkan hafalan rumus, jarang menggambar, tidak memverifikasi jawaban, dan kesulitan menjelaskan alasan di balik langkah penyelesaian. Keterampilan representasi verbal juga terbatas, dengan jawaban singkat tanpa penjelasan mendalam dan kurangnya kebiasaan mengungkapkan proses berpikir. Temuan ini mengindikasikan rendahnya kompetensi representasi matematis siswa dalam geometri. Oleh karena itu, diperlukan strategi pembelajaran yang mengintegrasikan representasi visual, simbolik, dan verbal serta menumbuhkan budaya refleksi dan komunikasi dalam pembelajaran geometri di sekolah dasar.
Kata kunci: *representasi matematis, pemecahan masalah geometri, peserta didik sekolah dasar, studi kasus.*

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INTRODUCTION

Understanding geometric concepts from an early age plays an important role in the development of students' spatial thinking abilities. Geometry is one of the branches of mathematics that not only requires logical ability but also visual and conceptual understanding. Unfortunately, many elementary school students still struggle to understand basic geometry concepts, such as flat shapes. This difficulty is often caused by a learning approach that emphasizes mechanical mastery of formulas rather than a deep understanding of the concepts. As a result, students tend to solve problems procedurally without understanding the meaning behind the formulas they use (Kamaluddin & Widjajanti, 2019).

In the process of learning mathematics, mathematical representation becomes an important aspect because it can reflect the way students think in understanding, organizing, and communicating mathematical ideas. NCTM (2000) mentions that the ability to represent mathematical concepts is one of the five important processes in learning. Mathematical representation is divided into three main forms, namely: (1) visual representation, such as images and diagrams; (2) symbolic representation, such as numbers and formulas; (3) verbal representation, which is an explanation in oral or written form regarding the steps to solve a problem. According to Duval in Saragih and Ramadhani (2024), students must be able to switch and coordinate various forms of representation to build a comprehensive understanding of mathematics.

Unfortunately, in reality, many students tend to focus solely on symbolic representations, such as formulas, without understanding their connection to visual forms and verbal explanations. In the context of geometry, this tendency becomes a serious problem because geometric material is closely related to spatial and visual understanding. Therefore, a learning strategy is needed that encourages students to use and integrate the three forms of representation in a balanced manner. One of the indicators of successful mathematics learning is the students' ability to convey and connect various mathematical ideas through appropriate representations.

Several studies have provided insights into learning strategies that can enhance students' representation skills. Sari and Dasari (2025) compared the effectiveness of the Jigsaw type cooperative learning with the "Student Facilitator and Explaining" model and found that the Jigsaw model was more capable of enhancing students' symbolic representation. On the other hand, Nugroho and Septianisha (2025) demonstrated that the GeoGebra-based STEM approach helped students in developing visual and symbolic representations simultaneously.

A case study by Annisa et al. (2025) shows that the use of e-modules based on the Realistic Mathematics Education (RME) approach can enhance students' mathematical representation abilities, especially in visual and verbal aspects. By using real and interactive contexts, students find it easier to connect symbols, images, and explanations. Meta-analysis by Rahmy & Sutiarso (2025) also shows that the Problem Based Learning model has a significant impact on improving representation skills at various educational levels.

On the other hand, research by Zulfa and Roza (2023) revealed that elementary school students showed different variations in representation depending on their level of mathematical abilities. Students with high ability in their study tended to be more flexible in using all three forms of representation in an integrated manner, whereas students with low ability often rely on only one type of representation. This indicates the need for a differentiated approach in geometry learning so that all students can develop according to their potential.

Furthermore, Sulastri et al. (2022) found that students' verbal representation abilities tend to be lowest compared to other forms of representation. This indicates that although students can write symbols or draw shapes, they often cannot explain their thinking process well. The low level of verbal representation can hinder students' ability

to reflect and understand conceptually. Therefore, it is important for teachers to stimulate explicit mathematical communication during the learning process.

At the international level, especially United States, the study by Stylianou et al. (2017) states that students' success in solving mathematical problems is positively correlated with their ability to use effective visual representations. This study also emphasizes the importance of explicit training in translating one type of representation to another, such as converting visual information into symbolic form and vice versa. The transfer between representations becomes the foundation for building flexibility in mathematical thinking.

Furthermore, a study conducted in the western United States, Ching et al. (2021) in their research assert that the ability to represent is not only a visualization aid, but also a means to develop better conceptual understanding and mathematical communication. They emphasized that the integration of representational tasks in mathematics learning could broaden the scope of students' thinking skills.

The challenge in mastering mathematical representations among students is also related to the limitations of the learning media used. In many elementary schools, the learning process still relies on lecture methods and conventional problem-solving exercises. Teachers rarely use visual aids, interactive technology, or adequate contexts to bridge the understanding of geometric concepts. As a result, students do not gain meaningful and in-depth learning experiences. This is exacerbated by the lack of teacher training in implementing representation-based learning, resulting in lesser classroom innovations to promote the learnng of geometry effectively.

In the context of the independent curriculum that emphasizes strengthening competencies and differentiated learning, mastery of representation becomes increasingly relevant. Students are expected to construct knowledge through various approaches and convey their understanding in appropriate forms of representation. Visual, symbolic, and verbal representations not only reflect individual understanding but also serve as means of communication and collaboration in learning activities. Therefore, strengthening mathematical representations becomes an important part of shaping students to be critical and creative thinkers.

However, despite the numerous studies highlighting the importance of representation, there are still few studies that specifically explore the forms of representation used by elementary school students in the context of two-dimensional geometry learning. A thorough study of this phenomenon is needed, considering that the age of elementary school children is a critical period in the formation of the foundations of mathematical thinking, which will impact the subsequent stages of learning.

Based on the initial observations conducted at SDN Brangkal 1, it was found that fifth-grade students still predominantly use a procedural approach and show limitations in connecting visual forms, symbolic representations, and verbal explanations when solving two-dimensional geometry problems. For example, some students could state the formulas for the area and perimeter of a rectangle, but had difficulty in drawing the shape or explaining the reasons for the steps they took. This indicates a gap between procedural mastery and conceptual understanding amongst the student.

These conditions underscore the importance of this research, which aims to explore how visual, symbolic, and verbal mathematical representations are used by fifth-grade students in solving plane geometry problems. This study uses a qualitative approach with a case study design to deeply uncover the thinking patterns and representations of the students. By understanding how students utilise various forms of representation, teachers can design more effective learning experiences that align with the cognitive needs and characteristics.

The problem formulation in this research is: "What is the form of mathematical representation of fifth-grade students at SDN Brangkal 1 in solving flat geometry problems?" The purpose of this research is to describe and analyze the form of

mathematical representation of fifth-grade students at SDN Brangkal 1 in solving flat geometry problems, with a focus on visual, symbolic, and verbal representations.

In addition, this research is expected to contribute to the field of primary education, both theoretically and practically. Theoretically, the results of this research can enrich the literature on the mathematical representation abilities of elementary school students. Practically, these findings can serve as a reference for teachers in designing learning strategies that accommodate the representation needs of students. Learning that encourages students to think visually, symbolically, and verbally simultaneously is believed to enhance a more comprehensive understanding of mathematical concepts, particularly geometry. Strengthening this aspect also has the potential to support the development of students' numeracy competencies within the context of the Pancasila student profile.

Thus, this study not only has academic relevance but also brings real implications for improving the quality of mathematics learning in elementary schools.

METHOD

This research is a qualitative study with a case study design, aimed at exploring students' mathematical representations in solving two-dimensional geometry problems. This approach was chosen because it is suitable for understanding phenomena in depth within a real and limited context. Case studies are used when researchers want to capture the complexity of students' learning processes in a specific classroom context (Yin, 2018).

The research was conducted at SDN Brangkal 1, Gemolong District, Sragen Regency. The participants of the research were fifth-grade students totaling 27 individuals. Ten students were then purposively selected for interviews, considering their level of mathematical ability (high, medium, and low) based on daily test scores and the teacher's consideration (Creswell, 2014). This selection aimed to obtain varied data in terms of the forms of representation used.

Interviews were conducted with one mathematics teacher who taught fifth grade at SDN Brangkal 1. The teacher interview aimed to obtain contextual information regarding geometry learning and the characteristics of students in the class, while the student interviews were conducted to explore the thinking processes and representation strategies used in solving geometry problems.

The data analysis technique used is thematic coding, as explained by Miles et al., (2014). The analysis was conducted through three stages, namely: (1) data reduction, by selecting relevant data from the interview results; (2) data presentation, in the form of narratives and thematic tables to identify the representation patterns found; and (3) making conclusion, which was carried out by interpreting the analysis results to identify the dominant forms of representation and their relationship with students' understanding. To ensure the validity of the findings, source triangulation was applied by comparing information from different participants (between one teacher and ten students). In addition, member checking was also conducted by requesting confirmation from teachers and students regarding the data interpretation from the interviews analysed by the researchers.

With this method, the research is expected to provide a comprehensive and in-depth picture of how fifth-grade students at SDN Brangkal 1 use visual, symbolic, and verbal representations in solving flat geometry problems.

RESULTS AND DISCUSSION

This research aimed to explore the forms of mathematical representation of fifth-grade students at SDN Brangkal 1 in solving plane geometry problems. Based on the results of the teacher and students' interviews and analysis of students' responses in solving geometry problems, it was found that students used three different types of

representations, namely symbolic, visual, and verbal. All three types of representations reflected the thinking styles and strategies of each student in solving mathematical problems, particularly in the topic of two-dimensional geometry.

All ten students involved in the study demonstrated a dominant preference for symbolic reresentation: that is, solving problems directly using formulas, without the use of drawings or explanatory notes. Three used a combination of visual and symbolic representation, that is, drawing the shapes first before using the formulas, while only one student explicitly used verbal representation, that is, explaining the reasons for the steps taken to solve the problems..

The results of the interview with the classroom teacher also revealed that most students are accustomed to memorizing the formulas of area and perimeter without a deep conceptual understanding. The teacher stated, "Children usually just look for the numbers in the problem and use the formula." "Rarely do they draw or explain why they use that formula." This reinforces the suspicion that the learning process is still dominated by a procedural approach, rather than a conceptual one.

This findings is in line with Duval's perspective in Saragih and Ramadhani (2024), wich explained that students are often not accustomed to switching between representations because the learning process does not provide space for that. Symbolic representation was the most dominant representation used by the students because it is the form that was most frequently taught and tested in schools.

Table 1 below is a summary of the mathematical representation forms used by ten fifth-grade students at SDN Brangkal.

Table 1. Results of Mathematical Representation Analysis

Initials of Students	Type of Representation		
	Symbolic	Visual	Verbal
S1	✓		
S2	✓	✓	
S3	✓		
S4	✓	✓	
S5	✓		
S6	✓		
S7	✓	✓	✓
S8	✓		
S9	✓		
S10	✓		

Analysis Based on Types of Representation

a. Symbolic Representation

Symbolic representation is the most dominant form used by fifth-grade students at SDN Brangkal 1. Based on the results of observations and interviews, ten out of ten students completed the questions about the area and perimeter of flat shapes by directly writing down the formulas, such as: "*Luas = panjang x lebar = 10 cm x 6 cm = 60 cm*^{2}" "Area = length x width = 10 cm x 6 cm = 60 cm²." This answer shows a pattern of solving based on memorizing formulas that is procedural, not conceptual.

However, when student were asked why they used that formula, the students could not provide a conceptual reason. A student said, "*Saya menggunakan rumus ini karena sudah hafal dari pelajaran kemarin*" or "I used this formula because I memorized it from yesterday's lesson." This tendency indicates that the student's

thinking process tends to rely on short-term memory and does not yet fully reflect conceptual understanding.

This finding supports the results of a previous study by Sari and Dasari (2025), which showed that mathematics instruction emphasizing rote memorization of formulas without exploring their underlying meaning tended to produce students who relied solely on symbolic representation. Such dependence on symbols often limits students' capacity for creative thinking and conceptual understanding.

According to Duval (2006), mathematical symbols are actually abstract and require mediation through other representations to be understood correctly. Without a mediator such as visual and verbal representations, symbols become entities devoid of meaning. This is reinforced by the National Council of Teachers of Mathematics, NCTM (2000), which emphasizes the importance of the ability to transition between representations in understanding mathematical concepts deeply.

In the context of the fifth-grade class at SDN Brangkal 1, this tendency also reflects that the teaching strategy applied still emphasizes achieving end results, rather than the thinking process. Teachers tend to consider students' success measured by correct answers, rather than by how they arrived at those answers. Therefore, the dominant use of symbolic representation without reinforcing other representations can lead to misconceptions and difficulties when facing problems based on real-life situations.

Mathematical procedures should emphasize the meaning of each procedure, including why the formulas are used, in the context of two-dimensional geometry. According to Steinle and Stacey (2004), a strong symbolic understanding must be built through connections with concrete experiences, visualization of shapes, and relative discussions. Therefore, teachers need to design learning experiences that encourage the integration of various types of representations, not just memorizing formulas and applying them mechanically.

b. Visual Representation

Although not dominant, visual representation began to appear in the responses of some students. Three out of ten students made an effort to draw flat shapes before solving the problem. They drew the shapes and labeled each side. After drawing, they then proceeded to the calculation stage. This shows the presence of a visualization process that supports students' spatial understanding of geometric shapes. One of the students explained, "*Kalau saya gambar dulu, saya lebih tahu mana yang panjang dan lebar. Jadi tidak salah hitung*." or "If I draw it first, I can better understand which is the length and which is the width. So I won't make a mistake in the calculations." This statement reflects the connection between visual representation and accuracy in calculations, while also indicating that the student is able to construct meaning of the concept through concrete visualization. Visual representation helps students to imagine shapes concretely, which is very important in geometry material.

This is in line with Goldin's (2002) view that visual representations serve as a bridge between abstract mathematical objects and the real experiences of learners. Visualization allows learners to see mathematical structures that are not visible through numbers and symbols alone. In geometry, visual representation is crucial because its concepts are spatial and relate to the shape, size, and position of objects.

Research by Nugroho and Septianisha (2025) showed that visual technology-based learning, such as GeoGebra, significantly enhanced students' visual representation abilities. Although the students in this study did not yet use digital tools, the tendency to draw before calculating indicates potential for developing conceptual understanding through visualization. Moreover, research by Ziatdinov and Valles (2022) showed that students who were accustomed to using

visualization, whether through hand-drawn images or digital tools like GeoGebra, tended to have a stronger conceptual understanding compared to students who relied solely on symbolic calculations. Visual representations also help reduce errors due to misconceptions of shape and size, especially in two-dimensional geometry.

In this study, it was found that the participants have not consistently used visualization as an initial strategy. This may be due to study habits that emphasize quick numerical solutions rather than shape representation. Teachers also tend not to explicitly encourage students to draw first before calculating.

In the literature of mathematics education, the process of sketching not only helps in recognizing shapes but also serves as a metacognitive strategy that helps learners check back on what they understand and do. According to Janvier (1987), visualization is an important part of the process of transposition of representations, where learners transform information from one form to another to better understand concepts.

Thus, although the number of students using visual representations is still small, these findings indicate the potential that can be further developed. The application of learning strategies that encourage the use of images, diagrams, or interactive visual media is greatly needed to strengthen students' understanding, especially in geometry. Teachers can facilitate this through drawing exercises, the use of concrete teaching aids, and the application of technology such as GeoGebra, AR (Augmented Reality), or other visual learning applications.

c. Verbal Representation

Verbal representation is the least used form by students in this study. Of the 10 students involved, only one child explicitly wrote an explanation of why they chose a particular formula and how they understood the relationship between the sides of the shape. The student said, "*Saya pakai rumus ini karena bangunnya persegi panjang. Sisi panjang di kali sisi pendek. Kalau hanya dijumlahkan itu keliling, bukan luas*." or "I used this formula because the shape is a rectangle. The long side multiplied by the short side. If you just add them up, that's the perimeter, not the area." This statement indicates that the student does not merely memorize formulas, but understands the relationships between types of flat shapes, their properties, and the mathematical operations used. The ability to explain the process of mathematical thinking verbally is an important indicator of deep conceptual understanding. Verbal representation not only reflects understanding but also demonstrates the students' ability to reflect on and communicate mathematical ideas coherently.

According to Annisa et al. (2025), this ability is an important indicator in understanding-based mathematics learning, not just rote memorization. Students who are accustomed to explaining their thought processes tend to be more resilient in facing problem-solving questions because they activate their metacognition during the learning process.

However, the low frequency of students using verbal representations indicates that this skill has not yet become part of the students' mathematical thinking habits. This may be due to learning habits that emphasize the end result rather than the thinking process, as well as the lack of space for discussion, reflection, and mathematical writing in the learning process.

Aulia and Sutiarso (2025) stated that verbal representation was rarely developed in classroom learning, as there was seldom room for exploration through discussion or reflective writing. However, verbal skills are an important foundation in mathematical communication, as emphasized by the National Council of Teachers of Mathematics, NCTM (2000). Without this knowledge, students struggle to articulate their mathematical ideas, making their learning process passive and procedural.

Thus, although only a few students displayed verbal representations, these findings indicate a significant opportunity for improvement. Teachers need to design learning that provides space for verbal exploration, whether through open-ended questions, verbal modeling, group discussions, or assignments to write mathematical explanations. Verbal representation should not just be an end product, but an integral part of an active and meaningful mathematics learning process.

Discussion of Findings

The findings in this study indicate that symbolic representation still dominates the way fifth-grade students at SDN Brangkal 1 solve problems related to the area and perimeter of 2D shapes. This dominance occurs because the learning culture in elementary schools is still strongly influenced by procedural-oriented teaching practices. This reflects the inheritances of a teacher-centered approach, where success is measured by the accuracy of final results rather than the process of understanding. This is consistent with previous research that mathematics learning focused on rote memorization of formulas tends to produce procedural and superficial understanding. When students rely solely on symbols without understanding the conceptual meaning behind them, symbolic representation becomes mechanistic, not reflective (Duval cited in Saragih & Ramadhani, 2024; Sari & Dasari, 2025). This condition reflects that the learning approach used in the classroom has not fully encouraged the exploration of concepts in a conceptual and multimodal manner.

On the contrary, visual and verbal representations are still limited. Only a small portion of the students used images to understand shapes and the relationships between sides, and only one student was able to explain the reasons verbally and in writing. However, as emphasized by NCTM (2000), a strong understanding of mathematics involves the ability to switch between representations. This is reinforced by Goldin (2002) and Xin et al., (2023) who stated that representations were an integral part of students' cognitive structures and played a role in building conceptual understanding, especially for students who experienced difficulties in learning mathematics.

The lack of visual representation indicates the low spatial abilities of the students. However, in geometry learning, visualizing shapes plays an important role in understanding two-dimensional geometry. Goldin (2002) states that visual representations serve as a bridge between abstract objects and the concrete experiences of learners. A study by Ziatdinov and Valles (2022) also confirmed that the use of visual tools such as GeoGebra had been proven to enhance geometry understanding through interactive exploration. Although digital media have not yet been applied in this study, the presence of students who first draw shapes indicates that a visual approach still has potential for development.

Meanwhile, verbal representation becomes a challenge in itself. Students are generally not accustomed to expressing mathematical ideas verbally or in writing. The minimal use of verbal representation also highlights the importance of learning strategies that open up space for discussion, reflection, and argumentation. In this context, the use of approaches such as Discovery Learning or Problem Based Learning (Aulia & Sutiarso, 2025; Rahmy & Sutiarso, 2025) can be a relevant alternative to enhance verbal representation skills. Ayyıldız Altınbaş et al., (2025) showed that multiple representations-based learning significantly enhanced concept understanding and self-efficacy among prospective mathematics teachers.

Another influencing factor is the local context and the readiness of the teacher. As mentioned by Hartati et al. (2023) and Rahmasari and Kuswanto, (2023), when mathematics learning was linked to students' daily lives, such as the use of Augmented Reality, it could enhance their engagement and understanding of concepts, including the forms of representation they use.

Therefore, these findings emphasize the importance of teachers designing learning experiences that not only target final outcomes but also facilitate the conceptual

and representational thinking processes of students. Strengthening mathematical representation skills, whether symbolic, visual, or verbal, must be an integral part of learning in elementary schools, especially in subjects related to geometry and problem-solving.

CONCLUSION

This research aims to explore the forms of mathematical representation used by fifth-grade students at SDN Brangkal 1 in solving two-dimensional geometry problems. Based on data obtained through interviews with one teacher and ten students, as well as the analysis of students' responses to the questions, it was found that there are three forms of mathematical representation that emerge, namely symbolic, visual, and verbal. Symbolic representation, such as the direct use of area and perimeter formulas, is the most dominant form used by the students. Meanwhile, visual representation such as drawing flat shapes before solving the problem is used by some children as an initial strategy to understand the geometry shape being asked. Verbal representation, which includes the ability to explain the steps and reasons for choosing a solution strategy, only appeared explicitly in one student. This indicates that this form of representation is still rarely used in the learning process.

The implications of these findings include the need to shift the approach to mathematics learning at the elementary school level from a procedural orientation to a more conceptual one. Teachers are advised to design learning that not only focuses on the use of formulas but also involves students in drawing two-dimensional geometry, explaining orally and in writing the reasons for choosing strategies, and discussing how to solve them. Additionally, it is also important to provide training to teachers on the significance of mathematical representation in concept building, as well as to provide learning media that allows for the exploration of visual and verbal representations..

This research has the limitation of being conducted in only one school with ten students as the participants of the study. Therefore, to obtain a more comprehensive picture, further research can be conducted by involving more schools and a larger number of students and teachers.

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