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# STUDENTS' DIFFICULTIES IN LEARNING THE CONCEPT OF CURVED-SIDED SPACES: A LITERATURE REVIEW

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## *ABSTRACT*

This study aims to identify and review several articles discussing students' learning difficulties in understanding material related to curved-sided geometric shapes in elementary schools. The research method employed is a literature study, in which data is collected from various scientific journals relevant to students' learning difficulties in comprehending curved-sided spaces. The findings indicate that students face multiple challenges, including difficulties in understanding basic concepts, remembering formulas, and applying appropriate problem-solving strategies. Common errors include procedural mistakes, difficulties in transforming information, and improper use of mathematical symbols. Factors contributing to these difficulties include a lack of interest in mathematics, the abstract nature of mathematical concepts, and insufficient practice in applying the concepts learned. This research is expected to serve as a recommendation for teachers and education practitioners to improve teaching methods and provide more intensive exercises to help students better understand the concepts related to curved-sided spaces.

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## INTRODUCTION

The study of students' learning difficulties in Indonesia, particularly in the area of geometry involving curved-sided spaces, is a multifaceted issue that encompasses various educational challenges. This topic is significant due to its implications for educational practices and student outcomes in mathematics. The need to improve educational standards and student performance in Indonesia underscores the urgency of addressing these difficulties. The following sections will explore the introduction, urgency, problems, previous research, significance, and the pros and cons of this topic.

The introduction of this topic is rooted in the broader context of educational challenges in Indonesia, where traditional teaching methods often prevail over modern, technology-enhanced approaches. The urgency of addressing learning difficulties in geometry is underscored by the need to improve students' spatial and geometrical understanding, which is crucial for their overall mathematical competence (Grobecker & De Lisi, 2000; Rasimin et al., 2024).

Field findings indicate that students struggle to understand the material related to curved-sided spaces, encountering various challenges and mistakes. Research by Rosyida and colleagues highlighted common error factors when students attempt to solve problems related to building curved-sided spaces. These mistakes occur when students implement strategies, formulate plans, comprehend problems, and check the results of their work (Rosyida et al., 2016). Other studies have explored the impact of room geometry on affective states and creativity, highlighting the potential benefits of curved spaces in educational settings (Strachan-Regan & Baumann, 2024).

The urgency of addressing learning difficulties in geometry is underscored by Indonesia's performance in international assessments, such as TIMSS, where students have consistently underperformed compared to their peers in neighboring countries (Jupri et al., 2014). Improving geometry education is critical for enhancing overall mathematical competence, which is essential for students' future academic and career opportunities (Zhang et al., 2014).

In mathematics, geometry is one of the fundamental concepts. Anugrah and Pujiastuti (2020) stated that geometry is a crucial area that must be studied and applied to understand various mathematical topics. Strong geometry skills enable students to tackle everyday

problems and develop higher-level mathematical thinking skills effectively. Some literature mentioned that designing educational spaces and materials that incorporate curved geometry can enhance students' learning experiences and outcomes (e.g., Corradi et al., 2019; Strachan-Regan & Baumann, 2024). Some students in Indonesia face several challenges in learning geometry, including a lack of spatial-geometrical understanding and difficulties in visualizing and transforming geometric figures (Grobecker & De Lisi, 2000).

Additionally, there is a significant gap in digital literacy among students and teachers, which hampers the effective use of technology in teaching geometry (Rasimin et al., 2024). (Purba et al., 2020) mentioned that the material on curved-sided spaces requires students to communicate their mathematical abilities appropriately, both in writing and orally. We consider why discussions related to curved-side geometry are a particular concern: if the material is conveyed incorrectly, the understanding received by students will be flawed.

A common problem that arises from inadequate communication is the issue of misconceptions. The material on curved-sided shapes involves abstract and complex concepts, such as volume and surface area of three-dimensional objects. Proper explanations help students grasp the definitions, formulas, and applications of these concepts without confusion or error. Curved-sided spaces refer to forms with one or more curved sides. Learning about the surface area and volume of curved-sided spaces is often relevant in everyday life. Mastering the construction of curved-sided spaces is crucial in mathematics education because it helps students interpret and analyze various everyday phenomena and supports their understanding of other materials.

Understanding the learning difficulties associated with the geometry of curved-sided spaces involves examining the various challenges students face in grasping geometric concepts, particularly those related to complex structures. These difficulties are compounded by factors such as teaching methods, student engagement, and the integration of technology into the learning environment. Addressing these geometry learning difficulties is critical for improving educational outcomes and ensuring that all students have the opportunity to succeed in mathematics.

To address the mistakes that students often encounter, it is important to analyze the errors present in their problem-solving processes. The goal is to understand the aspects that lead to these mistakes and their types, allowing for corrective actions to be taken. Therefore,

this study investigates common problems in students' understanding of the building materials for curved-sided spaces.

## METHOD

The method used in this study is a literature study. The literature research method involves a series of activities such as collecting data from library sources, reading, storing, and managing research materials, as explained by Zed (2008) and Solin et al. (2023). Articles were searched using the Herzing Publish or Perish (PoP) application, which refers to Google Scholar sources. The data searched in this tool is limited to the last 10 years, from 2015 to 2024, in accordance with the theme of the study. Based on this investigation, 12 scientific journals relevant to students' learning difficulties in the material on curved-sided geometric shapes were selected. The journals studied included the Journal of Education and Learning, Mathematics Education, and other research journals. These sources were chosen based on the criteria of relevance, quality, and contribution to the topic discussed.

After collecting the data, the researcher conducted a thorough analysis of the literature. This analysis involves identifying, classifying, and grouping data based on students' difficulties, as shown in Figure 1, the factors that cause these difficulties, and the solutions proposed by previous studies.

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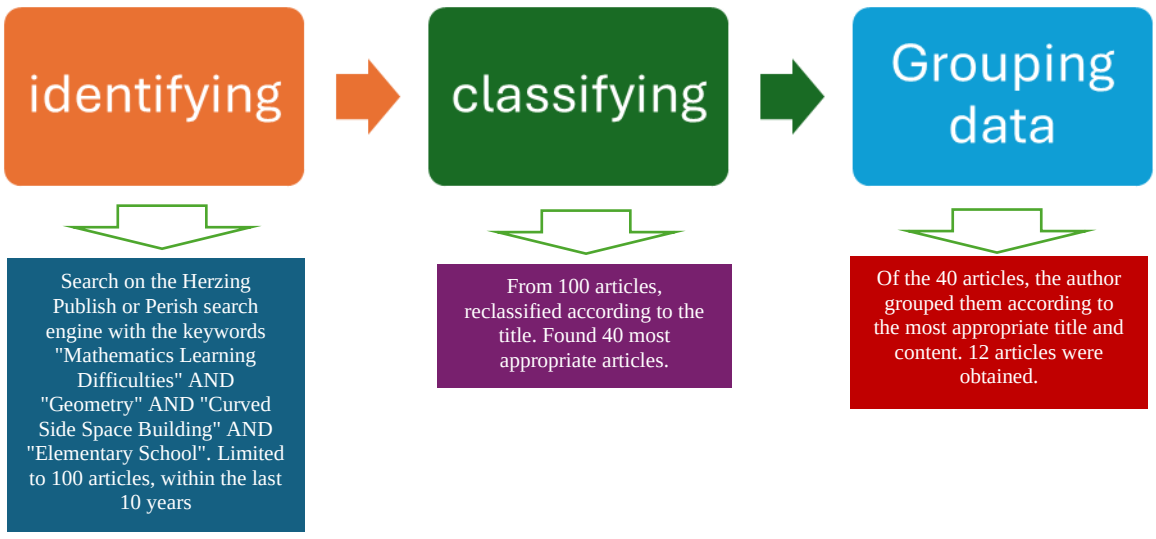


Figure 1. Articles Identification Process

The results of this analysis are then synthesized to provide a comprehensive understanding of students' learning difficulties and to offer recommendations to teachers and education practitioners regarding effective strategies to overcome these challenges. These recommendations are based on the evidence found in the literature studied, aiming to improve the effectiveness of learning materials for building curved side spaces.

This literature study is expected to serve as a foundation for further research and the development of more efficient teaching approaches, as well as to provide a deeper understanding of the challenges experienced by students in comprehending the building materials of curved side spaces.

## RESULT AND DISCUSSION

### *Results*

Articles search was conducted using the Herzing Publish or Perish search engine with the keywords "Mathematics Learning Difficulties," "Geometry," "Curved Side Space Building," and "Elementary School." In Herzing PoP, the search was limited to 100 articles published within the last 10 years. Furthermore, it was narrowed down based on the most relevant titles, resulting in the identification of 40 suitable articles. From these 40 articles, the author grouped them according to their titles and content, ultimately obtaining 12 articles. The findings reviewed and summarized by the researcher will be presented in the following table

Table 1. Results of the Analysis of 12 Relevant Journals

| No | Researcher & Year | Journal Name | Research Title | Research Results |
|---|---|---|---|---|
| [1] | Juweni T Tefi, Fitriani, and Yohanis Ndapa Deda | Math-edu: 'Jurnal Ilmu Pendidikan Matematika' | Analysis of Mistakes of Grade IX Students of SMPN 1 Amanuban Barat in Solving Mathematics Problems Subject Building Arched Side Spaces | Several students from SMPN 1 Amanuban Barat made mistakes while constructing a curved side space when completing math problems. Some of these mistakes include misunderstandings of the given problems, errors in process skills, difficulties in making transformations, and, ultimately, mistakes in writing the final answer. |
| [2] | Hafsyah, Ruslimin, and Pratiwi Pujilestari Alam | Diferensial: 'Jurnal Pendidikan Matematika' | Analysis of Mathematical Difficulties of SMPS PPM Students Rahmatul Asri on Building Materials for Curved Side Spaces | In the material on constructing a curved side space, students encounter difficulties in understanding the content, particularly in solving related problems. This challenge stems from their lack of grasp of the basic concepts involved in building curved side spaces and their difficulty in remembering the relevant formulas. |
| [3] | Widya Ayu Agustini and Nelly Fitriani | JPMI (Jurnal Pembelajaran Matematika Inovatif) | Analysis of Junior High School Students' Difficulties in Building Materials for Curved Side Spaces | In the material on constructing curved side spaces, students encounter difficulties in understanding the content due to their incomplete mastery of the basic concepts and challenges in memorizing the relevant formulas. |
| [4] | Mega Teguh Budiarto and Rudianto Artiono | MADIKA (Jurnal Magister Pendidikan Matematika) | Geometry and Problems in Learning (A Meta-Analysis Research) | Students face significant challenges in understanding geometry, including misperceptions, misconceptions related to visual |

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|---|---|---|---|---|
| | | | | processes and activities, difficulties in using procedures, principles, and concepts, as well as challenges in connecting and applying reasoning. |
| [5] | Agfa Martina, Toto' Bara Setiawan, and Susanto<br>(Martina et al., 2018) | Kadikma: Jurnal Matematika and Pendidikan Matematika | Analysis of Errors in Solving Curved Side Space Building Story Problems Based on Newman's Method in Auditory Learning Style Students | The interview results indicated that the main factor contributing to her difficulty in solving the story problem related to building a curved side space was her unfamiliarity with writing the formula in the provided columns and her inability to remember the formula necessary for solving the problem. |
| [6] | Cici Wulandari Sitorus, Fanny Selfinta Perangin-angin, Sazatul Asmal, and Wulan Dari | Relevan: Jurnal Pendidikan Matematika | Analysis of Students' Difficulties in Learning Materials to Build Curved Side Spaces | In the material on building curved side spaces, students encounter difficulties in understanding, particularly with complex concepts such as spheres. This situation indicates a gap in understanding between the students and the material being taught. |
| [7] | Arifin, Edy Yusmin, and Hamdani | Jurnal Pendidikan dan Pembelajaran (JPP) | Analysis of Student Learning Difficulties in Building Materials for Curved Side Spaces in Junior High School | Students struggle to understand the concept of building a curved side space and its related principles, which prevents them from using formulas to calculate its volume and surface area for problem-solving. |
| [8] | Abdurrachman Rahim | Tolis Ilmiah: Jurnal Penelitian | Students' Mistakes in Solving Problems of Building Materials for Curved Side Spaces | Students make mistakes in calculation operations due to the inaccurate use of mathematical symbols and have difficulty transforming story problems into mathematical language. Additionally, they struggle with understanding concepts, such as recognizing the elements of curved side spaces and applying the concept of surface area to these shapes. |
| [9] | Aldi Anugrah and Heni Pujiastuti | Jurnal Pendidikan Matematika | Analysis of Student Errors in Solving HOTS Problems Build Curved Side Space | Students experience difficulties in understanding the concepts needed to solve the problem and struggle to use mathematical formulas relevant to the problem's context. |
| [10] | Ida Nuraida | Teorema: Jurnal Teori dan Riset Matematika | Analysis of Errors in Solving Problems to Build Curved Side Rooms for Grade IX Students of SMP Negeri 5 Tasikmalaya City | Students experience difficulty understanding and solving problems related to building curved side spaces. Common types of errors include procedural mistakes, difficulties in organizing data, challenges in sorting information, errors in using mathematical symbols, struggles with mathematical manipulations, and mistakes in drawing conclusions |
| [11] | M. Dahlan and Ika Kurniasari | MATH Edunesa: Jurnal Ilmiah Pendidikan Matematika | Identification of Misconceptions of Junior High School Students in Building Materials for Curved Side Spaces Using Three Tier-Test | Errors found in the understanding of the building materials of curved side spaces reveal a misconception rate of 77.34% in this study, indicating that misconceptions still exist among grade IX junior high school students. The primary misconception occurs in understanding the concept of ribs, where students tend to associate this concept with flat-sided spaces rather than curved ones. Additionally, students experience false negative misconceptions regarding the concept of breadth. Conversely, false positive misconceptions arise in the concept of volume in the context of building curved side spaces, where students do not fully grasp the meaning of volume. |
| [12] | Sonny Yalti Duma, Ketut Linggih and Clara Citra Sangapa | Prosiding Seminar Nasional Pendidikan Matematika Uki Toraja | Analysis of the Mistakes of SMP Negeri 1 North Makale Students in Solving the Problem of Building a Curved Side Room | Errors made by highly talented students in the curved side space-building test questions are primarily due to a lack of attention to the formulas used. They tend to record the problem and what they know without following through with the necessary steps to complete it. Meanwhile, less gifted students make mistakes due to a lack of conceptual understanding, which results in their inability to solve problems. Errors |

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| | can also occur during the transformation process, often stemming from misinterpreting problems in the context of mathematical concepts or models, as well as from using improper calculation operations. |

Based on Table 1, we identified several difficulties faced by students, including a lack of full understanding of the concepts taught, particularly in solving math story problems. Students have struggled to translate the questions provided. Furthermore, we observed misunderstandings regarding visual processes and activities, as well as difficulties in using procedures, principles, and concepts, and challenges in connecting and applying reasoning. From the table above, these results can be categorized as seen in Table 2.

Table 2. Categories of Students' Difficulties in Learning Curved-Side Space Building Materials

| Indicator | Definition | Article | Sum |
|---|---|---|---|
| Difficulty in comprehending the problem | Students have difficulty identifying the steps required to correctly solve the questions. | (Tefi et al., 2022), (Rahim, 2022) | 2 |
| Errors in transformation | Students have difficulty applying the information they have understood into the correct mathematical form | (Tefi et al., 2022), (Rahim, 2022) | 2 |
| Challenges in mastering concepts and formulas. | Students have difficulty understanding the concept of curved-surface spaces and remembering the related formulas | (Hafsyah et al., 2022), (Martina et al., 2018), (Agustini & Fitriani, 2021), (Sitorus et al., 2023), (Arifin et al., 2017), (Anugrah & Heni Pujiastuti, 2020), (Duma et al., 2023) | 7 |
| Procedural difficulties | Students pay little attention to the information in the questions and struggle to identify what is already known and what needs to be proven. | (Budiarto & Artiono, 2019), (Nuraida, 2017), (Dahlan & Kurniasari, 2022) | 3 |

In Table 2, we classify some of the learning difficulties students face when studying materials related to curved-surface spaces. Difficulties in mastering concepts and formulas frequently arise, often due to the use of inappropriate strategies and media, resulting in suboptimal knowledge transfer. Table 3 categorizes the causes of these learning difficulties.

Table 3. Categories of Causes of Student Difficulties in Learning Curved-Surface Space Materials

| Category | Indicator | Definition | Article | Sum |
|---|---|---|---|---|
| Internal | Learning motivation | Students' enthusiasm for achieving learning goals. | (Arifin et al., 2017), (Sitorus et al., 2023), (Rahim, 2022), (Nuraida, 2017) | 4 |
| | Intellectual Ability | The ability of an individual to think abstractly at a high level. | (Duma et al., 2023), (Hafsyah et al., 2022), (Agustini & Fitriani, 2021) | 3 |
| External | Misconceptions | Students' lack of understanding of a concept is constrained by their experience and way of thinking | (Budiarto & Artiono, 2019), (Dahlan & Kurniasari, 2022) | 2 |
| | Concept mastery | The ability to understand meaning involves the ability to explain material in a simpler way, provide interpretations, and apply it. | (Martina et al., 2018), (Tefi et al., 2022) | 2 |

| | | | |
|---|---|---|---|
| Hurry | A lack of caution or careful consideration | (Anugrah & Heni Pujiastuti, 2020) | 1 |

**Discussion**

Based on the table of journal analysis results, various obstacles that students experience in understanding the building materials of curved side spaces have been identified. The analysis of students' obstacles or difficulties in remembering the material is discussed in articles by Tefi et al [1] and Rahim [8], which explain that students encounter several challenges when solving mathematical problems related to the construction of curved side spaces. One of the main issues is the difficulty in understanding the problems, where students are often constrained in interpreting the various information presented in math problems.

Studies by Gal and Linchevski corroborate this by exploring how visual perception affects understanding geometry in educational settings. They identified that students often struggle with figural processing due to perceptual organization and representation issues. Gestalt principles play an important role in how students perceive and understand geometric figures, which leads to difficulties in grasping the concept of curved lines (Gal & Linchevski, 2010). This can result in challenges in formulating the steps needed to solve problems appropriately. Additionally, students face difficulties in the transformation process, where they often struggle to apply the information, they have understood into the correct mathematical form. This can lead to errors in calculation and in writing answers.

Another factor contributing to students' difficulties with this material is the lack of practice in working on questions related to the content. To address this issue, it is essential to develop students' understanding of the material for building curved side spaces and enhance their skills in tackling mathematical problems. One effective approach is for teachers to provide more intensive exercises, explain mathematical concepts more clearly, and ensure that students have a solid understanding of various concepts before introducing more complex content.

The analysis of students' errors in the building materials of curved side spaces can be seen in the articles by Hafsyah et al [2] , Widya & Neli [3], Agfa, et.al [5], Cici, et.al [6], Arifin, et.al [7], Aldi & Heni [9] and Sonni, et.al [12] These articles explain that some students still face challenges in understanding and solving problems related to the building materials of curved side spaces. They encounter obstacles in mastering concepts and related formulas, such

as remembering formulas and problem-solving steps. While students can write down formulas, their responses are often incomplete, and they struggle to apply them correctly. This results in difficulties expressing their understanding, answering questions, planning their solutions effectively, recalling the steps they have learned, and verifying the correctness of their answers.

The challenges students face in solving problems related to building curved side spaces are common in mathematics education. Many students experience obstacles when solving mathematical problems, especially narrative ones. Data analysis shows that students struggle to understand mathematical concepts in curved surface geometry. This study highlights the difference in understanding the building materials of curved side spaces between students, with some students showing a slightly better understanding than others. These findings illustrate variations in how male and female students comprehend and engage with the material.

Several previous studies have also explored the learning difficulties students face in understanding the material. Steps to improve student understanding include implementing the Concrete-Representational-Abstract (CRA) approach and problem logging. The CRA approach is used to develop the mathematical learning process, particularly in learning abstract measurement concepts. This approach begins with concrete measurement concepts, progresses to their representation, and finally introduces them in abstract form. This gradual application helps students better grasp the concept of measurement and achieve optimal learning goals (Prasetyo et al., 2019).

The evidence indicates that students' difficulties in understanding the material have become a focus for improving the quality of mathematics learning. In addition to applying the CRA approach, teachers can enrich their instruction by using various formulas or visual aids and displaying them in the classroom. Teachers can also assign tasks systematically to each individual, such as summarizing all formulas related to the material, outlining various steps to derive the formulas, and providing examples of problems along with strategies for solving them. The goal is for students to fully understand the concepts of building curved side spaces (Priyo, 2011) and to more easily memorize various related formulas (Kustiyati, 2016)

With a deeper understanding of the challenges students face, educators can develop effective and appropriate learning strategies to help students overcome various obstacles in

understanding concepts and memorizing the mathematical formulas related to building curved side spaces.

The analysis of students' errors in this material is further explained in articles by Mega & Rudianto [4], Ida [10], Dahlan & Ika [11], which show that students often experience misconceptions and procedural errors in understanding the material. Procedural errors occur when students do not pay attention to the information in the questions, struggle to identify what is already known and what needs to be proven and have difficulty associating geometry knowledge with other areas of mathematics. This indicates that students face challenges in implementing the correct procedural steps to solve problems related to this material.

Misconceptions also present a significant challenge in understanding the building materials for curved side spaces. Students often misunderstand several concepts, such as the sphere, within the context of constructing a curved side space. These errors can hinder proper understanding of geometry and impact students' competence in solving problems effectively. In geometry, particularly in the construction of curved side spaces, educators must recognize and address both procedural errors and misconceptions experienced by students. Remedial actions are necessary to help students understand the correct procedural stages to resolve these issues. Additionally, the right approach must be applied to clarify misconceptions that may arise among students and teachers, ensuring that the concepts are understood accurately.

By improving students' understanding of procedural errors and misconceptions in the building materials of curved side spaces, it is hoped that the quality of geometry learning can be enhanced. A learning approach that focuses on students' procedural errors and misconceptions can help improve their understanding of geometry concepts and their overall problem-solving competencies. Therefore, educators play a crucial role in identifying, addressing, and preventing procedural errors and misconceptions in learning to build curved side spaces, which is essential for developing students' academic achievements. With a comprehensive understanding of these procedural errors and misconceptions, effective learning strategies can be designed to support students' understanding of geometric concepts. Through remedial efforts and appropriate guidance, it is hoped that students can overcome their challenges and improve their ability to understand and apply concepts more effectively.

From several previous studies, the author concludes that multiple problems arise for students learning geometry, particularly in building curved line spaces. First,

misunderstandings in geometry are prevalent, with many students experiencing misconceptions. Research by Istiyani et al. indicates that 47.5% of students had misconceptions about geometric concepts, especially concerning symmetry and angles (Istiyani et al., 2018). This highlights the need for targeted interventions to address these misconceptions.

*Second,* difficulties in recognizing relationships among geometric shapes are common. Students often struggle to identify the relationships between shapes, such as squares, due to the teaching methods that isolate each shape without comparison (Loc, 2017). This lack of relational understanding can hinder their ability to apply geometric concepts effectively.

*Third*, hird, the abstract nature of geometry poses challenges. Students often find it difficult to relate geometric concepts to real-world applications (Stone, 1971). This disconnection can lead to procedural errors and difficulties in problem-solving.

## CONCLUSION

Students in schools experience obstacles in understanding the building materials of curved side spaces due to several main factors, such as a lack of understanding of basic geometry concepts, ineffective use of learning media, limited variation in teaching methods, and psychological factors like motivation and interest in learning. This situation highlights the need for a more interactive and innovative learning approach to develop students' competence in the material.

In addition, many students struggle with understanding concepts and formulas related to curved side spaces and solving mathematical problems connected to that material. To address this, efforts must be made to improve students' understanding by applying the Concrete-Representational-Abstract (CRA) approach and using tools such as diagrams of curved side spaces to enhance comprehension. Procedural errors and misconceptions are also common challenges students face in this subject. Teachers need to actively identify and correct these errors through remedial actions and proper guidance. By doing so, it is hoped that the quality of geometry education will improve and that students' understanding of geometric concepts will be strengthened, enabling them to overcome learning obstacles related to curved side space materials more effectively in the future.

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