DOI: 10.56773/bj.v5i1.153
E-ISSN: 2809-8528

Brillo Journal
Volume 5, Issue 1, December 2025, pp. 1-14

ASSESSING STUDENTS' MATHEMATICAL LITERACY THROUGH PISA ITEMS IN THE SPACE AND SHAPE CONTENT

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Abstract

This study aims to analyze students' mathematical literacy in solving PISA problems, particularly in the space and shape domain. The research approach used is a qualitative approach. This type of research is qualitative descriptive approach. The study involved 27 ninth-grade students from one of Junior High School (JHS) in Kota Jambi. Data were collected through a written test using items adopted from the 2012 PISA Mathematics Released Problems, complemented by interviews to gain deeper insights. The results revealed that students' mathematical literacy abilities were categorized into high, medium, and low levels. The results show that most students demonstrate low mathematical literacy skills. Based on the three indicators of mathematical literacy, students in the high-ability category were able to formulate mathematical models, employ geometric concepts appropriately, and interpret the results within the given context. Students in the medium category were able to perform correct procedures but were unable to derive meaningful conclusions, while students in the low category experienced difficulties in all indicators. These findings indicate that students' mathematical literacy skills in geometry remain limited, particularly in reasoning and interpreting results. Therefore, learning activities that facilitate reasoning and provide more PISA-like tasks are needed to help strengthen students' mathematical literacy, especially in space and shape problems. Future research may also explore the use of locally contextualized PISA-like tasks to provide students with more meaningful and relatable problem situations.

Keywords: Geometry, Junior high school students, Mathematical literacy, PISA, Space and shape.

Abstrak

Penelitian ini bertujuan untuk menganalisis literasi matematika siswa dalam menyelesaikan soal PISA, khususnya pada domain ruang dan bentuk. Pendekatan penelitian yang digunakan adalah pendekatan kualitatif. Jenis penelitian ini adalah pendekatan deskriptif kualitatif. Penelitian ini melibatkan 27 siswa kelas sembilan dari SMP 4 Kota Jambi. Data dikumpulkan melalui tes tertulis yang menggunakan soal yang diadopsi dari PISA Matematika 2012 yang telah dipublikasikan, serta dilengkapi dengan wawancara untuk memperoleh pemahaman yang lebih mendalam. Hasil penelitian menunjukkan bahwa kemampuan literasi matematika siswa berada pada tiga kategori, yaitu tinggi, sedang, dan rendah. Hasil penelitian menunjukkan bahwa sebagian besar siswa menunjukkan kemampuan literasi matematika yang rendah. Berdasarkan tiga indikator literasi matematika tersebut, mahasiswa dalam kategori berkemampuan tinggi mampu merumuskan model matematika, menerapkan konsep geometri secara tepat, dan menginterpretasikan hasil dalam konteks yang diberikan. Siswa kategori menengah mampu melakukan prosedur yang benar tetapi tidak dapat memperoleh kesimpulan yang berarti, sedangkan siswa kategori rendah mengalami kesulitan pada semua indikator. Temuan ini menunjukkan bahwa keterampilan literasi matematika siswa dalam geometri tetap terbatas, terutama dalam penalaran dan interpretasi hasil. Oleh karena itu, kegiatan pembelajaran yang memfasilitasi penalaran dan memberikan lebih banyak tugas seperti PISA diperlukan untuk membantu memperkuat literasi matematika siswa, terutama dalam masalah ruang dan bentuk. Penelitian di masa depan juga dapat mengeksplorasi penggunaan tugas-tugas seperti PISA yang dikontekstualisasikan secara lokal untuk memberikan siswa situasi masalah yang lebih bermakna dan dapat dihubungkan.

Kata kunci: *Geometri, Literasi matematis, PISA, Ruang dan bentuk, Siswa SMP.*

How to Cite: Marsyandia, I. P., Nusantara, D. S., & Gustiningsi, T. (2025). Assessing Students' Mathematical Literacy through PISA Items in the Space and Shape Content. *Brillo Journal, 5*(1), 1-14.

INTRODUCTION

Geometry is a fundamental domain of mathematical knowledge that plays a crucial role in building the foundation for various branches of mathematics, such as Pythagorean theory, calculus, algebra, and sciences like astronomy through surface area representation (Rahmah & Susanah, 2020). The application of geometric concepts has great significance in everyday life, particularly in the fields of architecture, design, engineering, and various professions related planning and construction (Rahmah & Susanah, 2020). In education, geometry contributes to helping students develop their mathematical skills, develop problem-solving abilities, practice mathematical communication, and improve mathematical reasoning skills (Ma'rifah et al., 2019). All these abilities are elements of mathematical literacy.

Mathematical literacy is an important skill needed to face life in the present day (Gustiningsi et al., 2024). The OECD (2023) defines mathematical literacy as an individual's ability to formulate, apply, and interpret mathematics to solve problems in various real-life contexts. Mathematical literacy is related to real-life problems that arise in various situations. Students are required to be able to solve these problems by utilizing the knowledge and competencies acquired through learning experiences at school and in everyday life. Therefore, mathematical literacy is a very important skill for students (Damayanti et al., 2017).

However, the reality in the field shows that students' mathematical literacy is still relatively low. The PISA international report, published every three years, provides an analysis of the structure of education in Indonesia and shows the instability of Indonesian students' achievements over the last twenty years (Nusantara et al., 2021a). This can be seen from the table of mathematical literacy scores obtained by Indonesia.

From Table 1, Indonesia's scores have shown a consistent decline across the last three PISA assessment cycles, from 386 in 2015, 379 in 2018, and 366 in 2022 (OECD, 2016; 2019; 2023b). This indicates that the mathematical literacy skills of secondary school students in Indonesia remain low. Such findings highlight the need to conduct a more detailed analysis of the specific content areas assessed in PISA to identify where students experience the greatest difficulties and why these persist.

Table 1. Indonesia's PISA scores

Year	Indonesia's ranking	Number of participating countries	Score
2000	39	41	367
2003	38	40	360
2006	50	57	391
2009	61	65	371
2012	64	65	375
2015	63	70	386
2018	73	79	379
2022	69	80	366

(OECD, 2016; 2019; 2023b)

Within the PISA framework, there are four mathematical content areas used, namely quantity, uncertainty and data, space and shape, and change and relationships (OECD, 2023a). Of these four content areas, this study will examine the content of space and shape, which refers to the concepts of geometry and measurement.

The space and shape content in PISA is one of the challenges for students in Indonesia, because in answering PISA questions, students are required to be able to formulate problem- solving strategies (Qadry et al., 2022). Students' difficulties in solving geometry problems, which form the basis of space and shape content, include errors in understanding the questions, an inability to connect one concept to another in geometry, and a lack of retention of the material studied, so that the material appears difficult to store in students' memories (Budiarto & Artiono, 2019).

Several other studies have discussed students' mathematical literacy skills in solving PISA questions (Fadillah & Munandar, 2021; Qadry et al., 2022; Santika & Khotimah, 2023; Setyaningsih & Munawaroh, 2022). Although these studies provide information related to students' ability to solve PISA questions, there is a lack of research that specifically examines students' mathematical literacy skills in solving the 2012 PISA questions on the content of space and shape in the context of "revolving door". This context was chosen because it represents a real-world situation that requires spatial reasoning and geometric visualization, which are essential components of mathematical literacy. The problem involves understanding the relationship between two and three dimensional objects, interpreting the movement and area of rotating parts, and applying measurement concepts to solve practical issues. This analysis focuses on mathematical literacy indicators, namely formulating situations mathematically, employing mathematical concepts, facts, procedures, and reasoning, and interpreting, applying, and

evaluating mathematical outcomes. Through this analysis, it is hoped that a more detailed picture of students' mathematical literacy skills in space and shape content will emerge and become a basis for improving the quality of education.

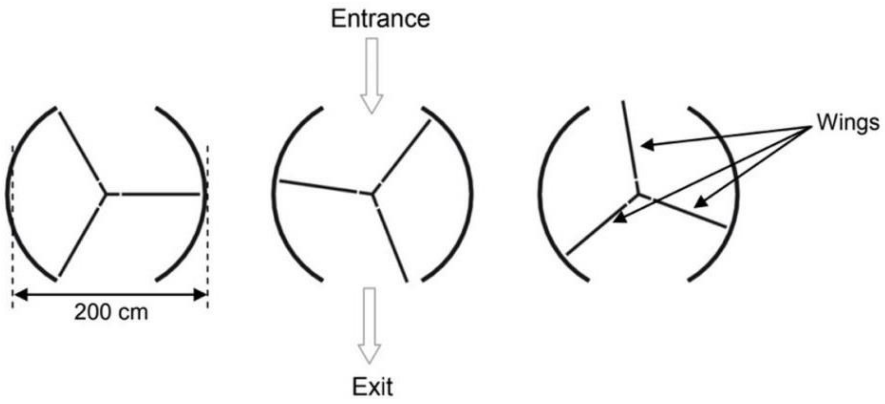
RESEARCH METHODS

The type of research used was qualitative descriptive research. This research was conducted on August 26, 2025, with the research subjects being one of the ninth-grade classes at Junior High School in Jambi City. There were 27 research subjects, consisting of 15 males and 12 females.

This study was conducted in several stages: (1) administering original PISA test items on space and shape with a duration of 60 minutes; (2) analyzing and evaluating students' responses using a rubric aligned with established mathematical literacy indicators (the rubric); (3) categorizing students' mathematical literacy proficiency into three levels (high, medium, and low); and (4) selecting three representative responses from each proficiency category to further examine students' understanding of mathematical literacy in the domain of space and shape.

This study used PISA questions on space and shape with a "revolving door" context at level 3 difficulty. Figure 1 shows the questions given to students.

A revolving door includes three wings which rotate within a circular-shaped space. The inside diameter of this space is 2 meters (200 centimeters). The three door wings divide the space into three equal sectors. The plan below shows the door wings in the three different positions viewed from the top.



What is the size in degrees of the angle formed by two door wings?

Figure 1. Students' mathematic literacy skills test on PISA 2012 space and shape content "revolving door"

The research data was collected from written tests and interviews. The written test consisted of level 3 space and shape content questions adopted from the PISA 2012 Released Mathematics Items book (OECD, 2016), which was translated and validated in terms of language by two validators, namely mathematics education lecturers. The questions were scored based on an assessment rubric that had been compiled and analyzed based on indicators of students' mathematical literacy abilities. The following indicators of mathematical literacy abilities can be seen in Table 2.

Table 2. Indicator of students' mathematical literacy

Indicator	Descriptor
a. Formulating situations mathematically	Identifying mathematical aspects and representing situations in mathematical form
b. Employing Mathematical concept, facts, and procedures,	To apply mathematical concepts, facts, procedures, and reasoning to solve mathematically problems
c. Interpreting, applying, and evaluating mathematical outcomes	Reinterpreting the results of the solution in the context of the question

Students' mathematical literacy skills were also assessed through interviews, in which a series of questions were asked to determine their ability to solve PISA questions on space and shape, as well as several factors that influenced their performance.

Next, the researchers grouped the students' abilities into three categories based on the students' answers. The categories were grouped into high, medium, and low. After categorization, the researchers conducted an analysis of three subjects representing each category. The guideline for categorizing students' abilities was adapted from Nurhayati et al. (2022), as presented in Table 3.

Table 3. Guidelines for categorizing students' skills

Interval	Category
$x \geq 70$	High
$40 < x < 70$	Medium
$40 \geq x$	Low

Table 3 shows the criteria for grouping students' mathematic literacy abilities based on the average score in solving PISA 2012 space and shape content questions. Students who get a score between more than 70 are categorized as high, between 40 and 70 are categorized as medium, and below 40 are categorized as low.

Meanwhile, the interview data were analyzed qualitatively through several steps: data reduction, data display, and conclusion drawing (Miles & Huberman, 1994). The results from interviews were then synthesized with the test findings through triangulation to obtain a more comprehensive understanding of students' abilities.

RESULT AND DISCUSSION

The mathematic literacy test question in Figure 1 requires students to analyze a revolving door with three wings. An illustration of the revolving door is provided, along with descriptions of the entrance, exit, and wings. Students are asked to calculate the degree of the angle of two door wings. This question requires students to identify information from the image, use geometric concepts, perform mathematical calculations, and provide conclusions in accordance with the context of the question.

The results of the mathematical literacy test on the PISA questions on space and shape with the "revolving door" content can be seen in Table 4.

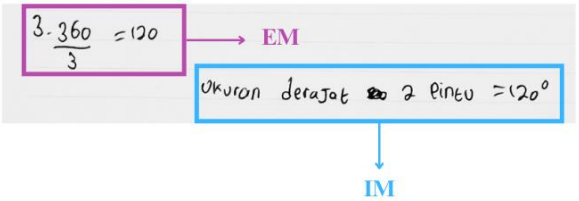
Table 4. Categories of students' mathematical literacy skills

Interval	Category	Number of students	Persentase
$x \geq 70$	High	8	29,63%
$40 < x < 70$	Medium	6	22,22%
$40 \geq x$	Low	13	48,15%

Table 4 presents the results of students' mathematical literacy skills test on the PISA 2012 space and shape content. In the interval of more than 70, 8 students were categorized as high with a percentage of 29.63%. In the 40 to 70 score range, 6 students were categorized as moderate, with a percentage of 22.22%. And in the score range below 40, 13 students were categorized as low, with a percentage of 48.15%. This indicates that most students demonstrated low mathematical literacy skills in solving space and shape problems.

In the space and shape content question, the mathematical literacy indicators assessed are as follows: Formulating Situations Mathematically (FM) is measured from students' answers who are able to identify mathematical aspects in the question, namely that the shape of the door is a circle with a degree of 360° and that the revolving door has 3 parts; Employing Mathematical Concepts, Facts, and Procedures(EM) is measured by the students' ability to divide the degrees of the circle by the number of door sections to

obtain the desired angle; Interpreting, Applying, and Evaluating Mathematical Outcomes (IM) is measured by the students' ability to conclude the answer obtained in the context of the revolving door angle in the question.



ENGLISH VERSION
the degree measure of the two doors = 120°

Figure 2. High-level student responses to questions on space and shape

Figure 2 shows the answers of students in the high category. The students did not write down the statements and questions in the problem, but they were able to use the correct concepts to find the solution. This can be seen from the students' answers, which show that they were able to perform the calculation correctly, namely dividing the degree of the revolving door, which is 360°, by the number of door wings, which is 3, to get 120°. From the result, the students were able to conclude that 120° is the degree measurement of the two doors.

Next, the researchers conducted interviews with students representing the high category to deepen the analysis of the students' written answers.

P : *How did you solve this problem?*
S : *It's divided, sis. It's a circular revolving door, right? It's 360 degrees, divided by 3, so it's 120.*
P : *Then what is 120?*
S : *If it's about the question, it's asking about the angle of the two doors. So that's the angle.*

Based on the interview results, students in the high-ability category showed good achievement on the three mathematical literacy indicators, although their responses were not yet fully complete**.** For the Formulate (FM) indicator, students were able to identify the essential mathematical elements of the problem and choose an appropriate strategy to begin the solution, although they did not explicitly state the known and unknown elements on the answer sheet. or the Employ (EM) indicator, students apply the correct facts by knowing that the circle has 360°, then students also apply the correct concepts and procedures by dividing 360° by the number of door wings, namely three doors to get the last 120°, for the interpret (IM) indicator, students can relate the results to the context of

the turnstile by concluding that 120 represents this finding shows that high-ability students can achieve the right solution.

Figure 3. Medium-level student responses to questions on space and shape

The student answer in Figure 3 shows that the student is at a medium level. The student can perform the calculation correctly, namely dividing the degree of the circular revolving door, which is 360°, by the number of door wings, which is 3, resulting in 120°. However, from the result found, the student is not yet able to draw a conclusion from the result obtained.

P : *How did you solve this problem?*
S : *It's divided, sis. A circle is 360 degrees, and there are 3 doors, so it's 120.*
P : *Then what is 120?*
S : *The result, sis.*

Based on the written response and interview results, students in the medium-ability category demonstrated partial achievement of the mathematical literacy indicators. . In the Formulate (FM) indicator, like students in the high-ability category, they can identify mathematical aspects within the problems; however, they do not explicitly state the known information and what is being asked in their written responses. For the Employ (EM) indicator, students correctly applied the required concept and procedure, as shown by their ability to divide 360° by the number of door wings to obtain 120°. However, for the Interpret (IM) indicator, students were unable to explain the meaning of the result in relation to the context of the revolving door. Although they performed the correct calculation, they could not draw a conclusion about what the value of 120° represents. This suggests that medium-ability students can carry out procedural steps, but their skills in interpreting results and connecting them to real-world contexts still need improvement.

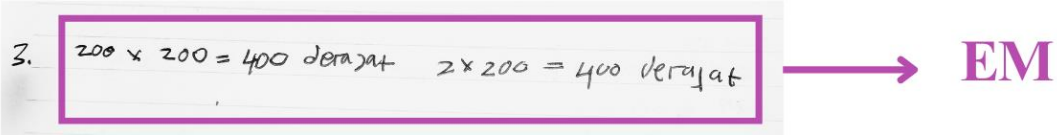


Figure 4. Low-level student responses to questions on space and shape

Figure 4 shows that students in the low category were unable to solve the problem. Students did not write down what they knew and what was asked in the question. Students were incorrect in identifying the information in the question used to find the final solution, as seen from the students' answers who wrote down and calculated using the number 200, which was information that was in the question but not used in finding the solution, thus incorrectly applying the concept needed to find the result. This also shows that students were unable to conclude the final answer obtained.

P : *Why do you use this formula?*
S : *I'm confused, sis. The question says 200, and then it asks about a 2-degree door, so I just multiplied it.*
P : *What's confusing?*
S : *I'm confused about what to calculate and what formula to use. I can't imagine how the revolving door works either.*
P : *Have you ever seen a revolving door like that?*
S : *Never, sis.*

Students in the low ability category showed difficulties in all three indicators of Mathematical Literacy. For the formulate indicator (FM), students have difficulty identifying key information from the problem and are unable to determine an appropriate plan to solve it. Judging from the answers of students who do not write down what is known and asked on the answer sheet, in addition, students are wrong in applying the facts, concepts, and procedures used, causing miscalculations and irrelevant solutions. This has an effect on the inability of students on the Employ (EM) indicator. For the interpret indicator (IM), students cannot relate their answers to the context of the problem and cannot explain the meaning of the results. These findings suggest that students with low abilities face fundamental challenges in understanding the problem, choosing valid strategies, and interpreting the results, suggesting that their conceptual understanding and mathematical reasoning require substantial support.

Interpretation of the analysis results

The results of this study indicate that students' mathematical literacy skills are still in the low category. This can be seen from the test results, where students were unable to meet all three indicators. This shows that the mathematical literacy of junior high school students still needs to be improved, especially in questions related to geometry and measurement.

Indicator 1: Formulating situations Mathematically (FM)

The results of the study indicate that students in the high and medium categories were able to meet the FM indicators in completing the space and shape content questions. However, they did not write the information they obtained on their answer sheets. This was demonstrated by the interview test, which showed that students were able to explain what they knew and were asked, as well as the solutions they had to find. This finding is in line with the research by Lestari and Effendi (2022) and Ridzkiyah and Effendi (2021) which shows that students are not yet able to communicate their answers in writing and tend to want to complete the questions immediately. Furthermore, students in the low category were not yet able to identify the information in the questions. This can be seen from the students' answers, who still had difficulty identifying the information that must be used to find the final solution to the space and shape content questions. This shows that students in the low category had difficulty formulating contextual problems into appropriate mathematical models.

This finding is in line with the opinion of Nusantara et al. (2021b), which stated that students often have difficulty identifying essential information in geometry problems. In this study, some students also showed errors in interpreting key information in the problem, which led to errors in the subsequent calculation process. Thus, students ' inability to meet formulaic indicators suggests that their skills in extracting relevant information and understanding the context of the problem still need to be strengthened through real-world mathematical tasks.

Indicator 2: Employing Mathematical concept, facts, procedures, and reasoning

In the Employ Mathematics (EM) category, the findings revealed that students in the high and medium groups were able to perform calculations by applying relevant mathematical concepts, as demonstrated by their ability to divide the degrees of the circle according to the parts of the revolving door. In contrast, students in the low group struggled to identify and apply the appropriate concepts, which led to incorrect solutions. Prior studies (e.g. Amalia et al., 2024; Setyaningsih & Munawaroh, 2022) similarly highlight that such errors often stem from limited conceptual understanding, resulting in the misuse of formulas. Moreover, some students in the low group left the items unanswered. Interview data indicated that these students were unfamiliar with the problem context specifically revolving door which hindered their ability to connect real-life situations with

mathematical concepts. This suggests that difficulties in interpreting the contextual setting constituted a major barrier to activating their mathematical literacy skills.

Indicator 3: Interpreting, applying, and evaluating mathematical outcomes (IM)

Regarding the IM indicator, the findings reveal that only students in the high-achievement group were able to interpret the results within the real-world context of the problems. In contrast, students in the medium- and low-achievement groups continued to face difficulties in interpreting their answers in relation to the problem context. Overall, these results suggest that students' mathematical literacy skills on the IM indicator remain limited at the medium and low levels. This aligns with the findings of (Lestari & Effendi, 2022; Salsabilla & Hidayati, 2021), who reported that students often fail to organize solution steps sequentially and to provide conclusions, indicating a lack of verification of their results.

The three indicators indicate that students continue to experience difficulties in solving PISA tasks related to space and shape. The findings suggest that such difficulties arise because students are not yet accustomed to engaging with real-world contexts that demand reasoning skills. Consequently, it is essential to provide students with greater exposure to PISA-type tasks, as these can foster their ability to apply mathematical knowledge, analyze problems, reason logically to reach solutions, and communicate their answers effectively (Gustiningsi & Somakim, 2021). This aligns with Nusantara et al. (2021a, 2021b), who emphasize the importance of integrating PISA-type tasks into classroom instruction to habituate students to contextual problem-solving based on reasoning.

CONCLUSION

This study concludes that the mathematical literacy skills of ninth-grade students in solving PISA 2012 space and shape problems are still predominantly in the low category. Based on the results of written tests and interviews, only 29,63% of students were able to meet all three mathematical literacy indicators formulating, employing, and interpreting mathematically. Students in the high-ability category demonstrated the ability to represent the problem accurately, apply the correct geometric concepts, and interpret the obtained results within the context of a revolving door. Students in the medium category

were able to execute the correct procedures but were still unable to provide conclusions related to the problem context. Meanwhile, students in the low category experienced difficulties in all indicators, particularly in identifying relevant information, selecting appropriate concepts, and interpreting mathematical results.

These findings show that students' difficulties are closely related to limited conceptual understanding, weak reasoning skills, and unfamiliarity with real-world contexts, especially those requiring spatial visualization. Therefore, students need more learning experiences that involve contextual, reasoning-based problems aligned with the PISA framework. Continuous exposure to PISA-like tasks, particularly in geometry and measurement, is expected to strengthen students' ability to formulate strategies, apply mathematical concepts appropriately, and interpret results meaningfully in everyday situations. Future research may also explore the use of locally contextualized PISA-like tasks to provide students with more meaningful and relatable problem situations.

ACKNOWLEDGMENT

This study was funded by the 2025 DIPA of Universitas Jambi (Contract Number: SP DIPA 139-03.2.693426/2025) under the early-career faculty research scheme. The author gratefully acknowledges the mathematics teacher and the students of Class IX at JHS 4 Kota Jambi for their invaluable contributions and active participation.

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