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Indonesian Students' Numeracy Skills Based On PISA Mathematical Problems In Secondary School: A Meta-Synthesis

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Abstract: Objectives: This study aimed to describe the Indonesian students' numeracy skills in secondary school in solving PISA mathematical problems based on four contents namely space and shape, change and relationships, quantity, uncertainty and data. Methods: A meta-synthesis was used in this study. The final 18 articles used in this study which were published in national and international journals in 2016 to 2023, obtained from databases in Publish or Perish software. This entire articles use descriptive qualitative research that describes the numeracy abilities of Indonesian students in solving PISA model questions. The included studies were structured using the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) 2020 flow diagram and analyzed using Braun & Clarke's six-step thematic analysis. Finding: The results of this study indicate that overall Indonesian students in secondary school still have difficulties in using mathematical operation, understanding problems, using strategies, and interpreting the results of solving the PISA model questions in terms of space and shape, change and relationships, quantity, uncertainty, and data content. Conclusion: Numeracy skills are fundamental for students to navigate and solve problems effectively, especially in assessments like PISA. Teachers were recommended to frequently provide non-routine problems like the PISA model, which can explore students' numeracy skills, so that students become accustomed to solving high-level problems and their numeracy skills also improve.

Keywords: numeracy skills, PISA mathematical problems, and meta-synthesis.

▪ INTRODUCTION

Numerical literacy is one of the skills defined by UNESCO in 2006 as one of the determinants of the nation's progress (Kemendikbud, 2017). This literacy is very important for students to master because it is closely related to the application of mathematics to their daily lives (Marhami et al., 2022). Leder et al. (2015) stated that numeracy is a concept used to identify the knowledge and abilities needed to accommodate the mathematical demands of private and public life and to participate in society as an informed, reflective, and contributing citizen. Numerical ability is also known as mathematical literacy. Mathematical literacy is a person's ability to formulate, apply, and modify mathematics in various contexts, including mathematical reasoning ability and using concepts, procedures, and facts to describe, explain, or predict phenomena or events. (Kuswidi, 2015; Lanya et al., 2021; Taufik & Zainab, 2021).

Numerical ability is one's quality measurement of education in a country (Kurniawati & Kurniasari, 2019). As yet, the Indonesian government has continued to improve the quality of education, which reflects the alarming results of the PISA (Program for International Student Assessment) (Marhami et al., 2023). Based on this international assessment, Indonesia is always ranked in the bottom 10 with an unsatisfactory score; even in 2018, the latest PISA score was 379, which is far from the international average score (OECD, 2019). This is what underlies the government's decision to replace the National Examination (NE) and focus on numeracy in the

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implementation of the Minimum Competency Assessment (MCA) as a provision to improve PISA scores in the next period (Kemendikbud, 2020).

There are 4 mathematical concepts tested in PISA questions (OECD, 2019) namely: (1) Space and shape, related to the subject matter of geometry which tests students' ability to recognize shapes, look for similarities and differences in various dimensions and shape representations, and recognize the characteristics of an object in relation to the position of the object ; (2) Changes and relationships, related to the subject matter of algebra where these relationships are also expressed in equations and various algebraic symbols, graphs, geometric shapes, and tables; (3) Number (quantity), related to the relationship between numbers and number patterns, including the ability to understand size, number patterns, and everything related to numbers in everyday life; and (4) Uncertainty and data related to statistics and probabilities that are often used in the information society.

In addition to content, there is also an assessment in the PISA study consisting of 6 levels, where level 1 is the lowest level while level 6 is the highest level. Johar (2012) explained that level 1 and 2 questions were included in the group of questions with a lower scale that measured students' ability to recognize facts and objects in the question. Questions at levels 3 and 4 belong to groups that demand students' ability to make connections between several concepts, ideas, and information to obtain new information to solve a problem, and students are able to change the information known to the question in the form of a mathematical model. Meanwhile, questions at levels 5 and 6 belong to groups of questions with a high scale that measure students' ability to analyze and think critically in solving problems and to be able to relate back to the original situation.

The unfamiliarity of Indonesian students with solving characteristic mathematical problems such as questions and PISA is one of the causes of low numeracy skills at the international level (Wardhani & Rumiati, 2011). This is of course supported by the learning climate in schools, where teachers are not optimal in providing habituation to students in solving problems that require high-level thinking (Hadi & Novaliyosi, 2019) hence that learning using problem instruments such as PISA is less familiar (Know & Do, 2019).

In several countries, assessments and surveys have also been implemented by state ministries and authorized institutions to measure the basic readiness of students, for example, in Australia, the ACER assessment measures the readiness of students in that country in terms of numeracy (Forgasz & Hall, 2019). Seeing this phenomenon, there have been many studies regarding numeracy literacy in Indonesia in recent years. Baharuddin et al. (2021), Perdana & Suswandari (2021), and Sari et al. (2021) especially regarding numeracy skills based on PISA results (Munfarikhatin et al., 2022) such as measuring students' mathematical numeracy abilities with PISA questions to find out the level and components of the process (Mansur, 2018; Natsir & Munfarikhatin, 2021) and others.

This study focuses on analyzing the numeracy abilities of students in Indonesia when solving PISA model questions, which are grouped based on 4 PISA content areas. The analysis was carried out based on previous studies related to this matter in order to obtain a conclusion regarding students' numeracy abilities in solving PISA model problems that can be used as a joint reflection and as a comparison of the results of other studies, especially in the international sphere.

▪ METHOD

Research Design

This research is a meta-synthesis study. Meta-synthesis aims to answer research questions by summarizing various research results that have been carried out and acknowledged as valid (Walsh & Downe, 2005). Walsh & Downe also stated that meta-synthesis is a relatively new technique for analyzing qualitative data derived from individual research that aims to re-analyze the results of the research. In other words, meta-synthesis aims to summarize the results of qualitative research that have been found previously. Meta-synthesis can be an attempt to understand various advances in research that are growing rapidly.

Study Search Procedure

The publications connected to the numeracy skills of secondary school students' Indonesia in solving PISA model questions were selected from academic databases including Google Scholar, Crossref, and Scopus. These databases were chosen because they are accessible through the Publish or Perish Software (Harzing, 2007). The articles that became the reference were articles published after the 2015 PISA assessment, from 2016 to 2023, taken from reputable national and international journals. The descriptors or keywords entered into the Publish or Perish Software were " numeracy skills" and "PISA mathematical problems". These keywords were chosen to extract relevant articles. The screened data was then sorted using a flow diagram based on PRISMA 2020.

Inclusion and Exclusion Criteria

Inclusion and exclusion criteria provide a basis on which the reviewer draws valid and reliable conclusions (Meline, 2006). The studies that were chosen for inclusion with the criteria: (a) The studies published in 2016 to 2023; (b) The subject of studies had Indonesian students in secondary school; (c) The studies used qualitative design; and (d) The studies about numeracy skill in solving PISA mathematical problems. The selected articles were filtered using predetermined inclusion criteria.

Data Analysis

The results of this research analysis are in the form of qualitative data adapted to the important components in the meta-synthesis. The meta-synthesis steps according to Francis & Baldesari (2006) are as follows: (1) Formulating the research questions; (2) Conducting systematic literature research; (3) Conducting screening and selecting appropriate research articles; (4) Analyzing and synthesizing qualitative findings; (5) Maintaining quality control; and (6) Summarizing.

▪ RESULT AND DISSCUSSION

The data collected from Harzings' Publish or Perish was organized using the PRISMA 2020 flow diagram, as shown in figure 1. There were three stages of the research paper selection using the PRISMA flow diagram: identification, screening, and included.

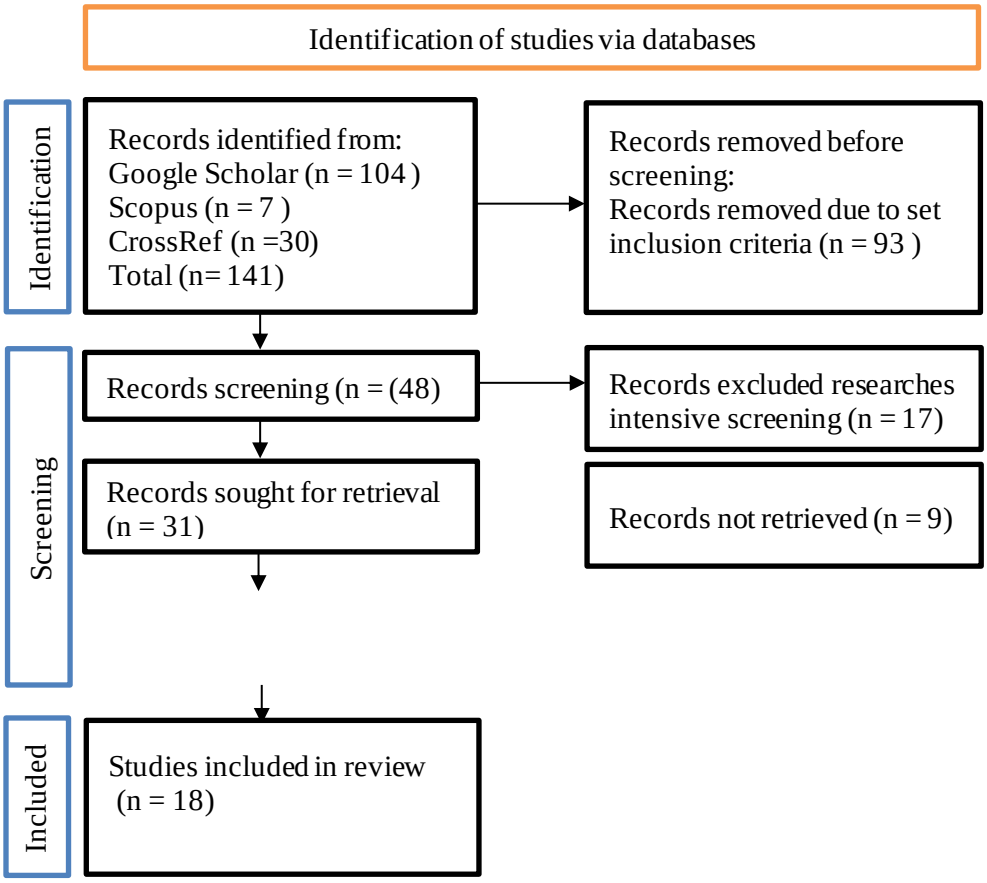

Figure 1. Data selection using prisma flow diagram

The numeracy skill in solving PISA mathematical problems were utilized to create initial codes, emphasizing the 18 studies included in the meta-synthesis. The analysis of these articles that have been selected uses the same research method, namely descriptive-qualitative. These articles will be described one by one according to the components to be analyzed in each journal. Important components that will be analyzed in each journal include research objectives, mathematical content used, to the research results obtained. The journal data is processed according to the steps mentioned above in order to obtain the essence of the results of design research. Data from 18 articles that have been analyzed is listed in the Table 1.

Table 1. Studies highlighting of students' numeracy skills based on PISA problems

Article	Author/s & Year Published	Content Of PISA	Intervention	Sample of Students
1.	Fitriana & Lestari, 2022	space and shape	level of mathematical spatial ability	39 Obs, 3 Int
2	Masfufah & Afriansyah, 2021	space and shape	Level 1 and 2	4 Obs and Int
3.	Munfarikhatin & Natsir, 2022	space and shape	Using 6 level of PISA	30 Obs

4.	Farida Et Al., 2021	change and relationships	mathematical abilities level	22 Obs, 3 Int
5.	Hamidah & Widodo, 2022	change and relationships	mathematical abilities level	19 Obs, 8 Int
6.	Pujiana & Sintiani, 2022	change and relationships	mathematical abilities level	6 Obs
7.	Maulana & Hasnawati, 2016	change and relationships, space and shape	Level of numeracy skills	20 Obs
8.	Noviana & Murtiyasa, 2020	Quantity	mathematical abilities level	32 Obs
9.	Khoirudin Et Al., 2017	Quantity	Students' low numeracy skills	3 Obs & Int
10.	Ridzkiyah & Effendi, 2021	change and relationships, quantity, *Uncertainty and Data*	mathematical abilities level	12 Obs
11.	Amelia et al., 2020	*Uncertainty and Data*	Based on 3 process	23 Obs, 5 Int
12.	Andari & Setianingsih, 2021	change and relationships	Indonesian Cultural Context	30 Obs, 3 Int.
13.	Utari & Zulkardi, 2019	Quantity	the context of coconut	30 Obs.
14.	Sahidin & Sari, 2022	*Uncertainty and Data*	mathematical abilities level	30 Obs, 3 Int
15.	Nurutami et al., 2019	space and shape	levels in the PISA questions	36 Obs.
16.	Salsabila et al., 2021	Quantity	Students' high numeracy skills	1 Class Obs,
17.	Kholid & Nissa, 2022	change and relationships	Papuan Local Context	6 Obs
18.	Sari et al., 2016	Quantity	Level of numeracy skills	6 Obs and Int

Eighteen studies including the content of PISA mathematical problem, measured variables, and the 349 total subject in these studies, are detailed in Table 1. All of studies were about analyzing students' numeracy skills in solving PISA model problems. These experiences were grouped and analyzed using the six-step thematic analysis, resulting in four themes: (1) using mathematical operation, (2) understanding problems, (3) using strategies, and (4) interprenting the result. Combining all themes revealed one meta-theme: students' numercay skills in PISA problems. The identified themes and meta-theme are described below.

Theme 1. Using Mathematical Operation

The basic mathematical operations of addition, subtraction, multiplication, and division are often introduced at the early stages of education. According to Baroody (2006), these operations are not only essential for performing calculations but also for developing number sense and arithmetic fluency in young learners. Research by Fuson (1992) emphasizes the importance of conceptual understanding over rote memorization,

suggesting that students who grasp the underlying principles of these operations perform better in more advanced mathematical tasks.

Of the 18 articles reviewed, students' difficulties in using mathematical operations when solving PISA problems were mostly found in the space and shape. This content covers various phenomena that are found everywhere in our visual and physical world, for example: patterns, object properties, positions and orientations, representations of objects, coding of visual information, navigation, and dynamic interactions with real forms (OECD, 2013). Space and Shape related to the subject of geometry. Geometry is an important branch of mathematics because it aims to facilitate students to think critically when solving problems (Aydogdu, 2014). Some students are not able to apply the application of mathematics, especially geometry in their daily lives, they are even unable to solve almost the same problems in daily life (Adolphus, 2011). Wardani (Setiawan & Dafik, 2014) stating PISA questions on space and shape content requires reasoning and problem-solving skills.

Fitriana & Lestari (2022) chose 3 students who represented categories with low, medium, and high ability levels from 39 students who were given PISA model questions with geometry content. They were interviewed and found that they still had difficulty using mathematical operation and writing down the information from the questions. Otherwise, Pujiana & Sintiani (2022) stated that students with moderate abilities tend to be able to identify problems and design strategies well, but still, there are students who are unable to answer correctly based on these strategies, and there are calculation errors.

Nurutami et al. (2019) mentioned that 35 out of 36 students had not been able to answer the questions, Misunderstanding errors were mostly made by students in solving PISA questions, they could not process the information they knew and the questions asked.

Research Munfarikhatin & Natsir (2020) found that as many as 80% of students who were given Pythagorean questions occupied a level below 1 on the components of the mathematical aspect, representation, reasoning, and argument, devising strategies and solving problems, using mathematics tools. Students were not able to use mathematical operations correctly and were not able to use their mathematical skills to solve the easiest math problems. This reinforces the statement that Indonesian students are only able to answer PISA level 1, 2, and 3 questions, while for the fourth level, only a small proportion are able to complete them. (Edo et al., 2013).

Theme 2. Understanding Problems

Understanding problems in mathematics is a critical aspect of mathematical learning and problem-solving. It involves not only the ability to perform calculations but also the capacity to comprehend, interpret, and apply mathematical concepts to various situations.

Among the four PISA contents, many students were found to have difficulties understanding the problems in the change and relationship content. It was because change and relationship relates to daily life in describing, modeling, and explaining growth and phenomena (OECD, 2019; Nusantara et al., 2020). However, the importance of change and relationship content is not in line with the fact that students in Indonesia are less able to solve PISA type math problems (Wijaya et al., 2014). A common mistake students make when working on PISA questions is interpreting the problems given (Fadillah &

Ni'mah, 2019). Likewise, in Masfufah & Afriansyah (2021) research, it was found that students' ability to interpret questions into mathematical sentences was still low so they had difficulties applying formulas that they already knew. For example, students understand the beam formula, but when given problems, When given a problem, students do not understand the direction or intent of the question, making it difficult for them to apply the formulas they have learned and solve the problems, especially in the daily life content.

Some researchers categorize students into 3 groups: high, medium, and low. Difficulty in understanding problem mostly happen in the low group, like students tend not to write down in detail what is being asked and the strategy used in answering the question (Kafifah et al., 2018). This is in accordance with the interview conducted by Andari & Setianingsih (2021) with a student from the low group. It was found that students with low numeracy abilities still had difficulties identifying aspects and variables in mathematical problems. While students with high and moderate mathematical abilities can understand the variables used and carry out appropriate arithmetic operations (Putra & Vebrian, 2019; Santoso & Setyaningsih, 2020).

Theme 3. Using Strategies

The use of strategies becomes a crucial point in the sequence of solving mathematics problems. After understanding the given problem, students should be able to determine which steps to use in solving it. However, students often make mistakes in determining the strategies to use, resulting in the problem not being solved properly. This is in line with several studies analyzing students' numeracy skills at the stage of using strategies to solve PISA problems in the quantity content.

Quantity content includes the ability to reason quantitatively, present something in the form of numbers, understand mathematical steps, count, and make judgments (OECD, 2014). Many quantity content questions are implemented in everyday life, such as in exchanging currency rates, determining bank interest, shopping, calculating taxes, measuring time, measuring distance, and so on (Anisah, Zulkardi, & Darmawijoyo, 2016).

Noviana & Murtiyasa (2020) stated that numeracy skills in solving problems were still relatively low at 7.13%. This was obtained from the results of giving 2 high-level quantitative content PISA questions, namely levels 5 and 6. From the results of the answers and student interviews, it was found that students still did not use the strategy correctly, resulting in wrong conclusions or final answers. This is due to a lack of understanding by students regarding the questions given, so that after trying to register things that are known from the questions, students have difficulty compiling strategies. Accordingly, research of Utari & Zulkardi (2019) obtained that only seven students out of 30 who were able to apply strategy through the different procedure, which led to the mathematical solution and conclusion which was familiar and complete.

Slightly different in taking the subject of the studies above, Khoirudin et al. (2017) focusing research on the numeracy skills of quantity content in students with low abilities. From the results of his research, it was found that the abilities of these students only reached level 1 which students still difficult in using effective strategies to solve PISA mathematical problems. In contrast, research from Salsabila et al. (2021) focuses on students' high numeracy skills, and based on the results of the analysis, it is found that

there is a student who has a high level of mathematical literacy equivalent to level 5. It means that student can use strategies effectively to solve PISA problems. Similarly, Sari et al. (2016) stated that of the 6 students, it was found that 2 students had level 5 numeracy skills in quantity content. So it is said that even though Indonesia's PISA scores are low and there are many studies that support this, it is possible that there are still other Indonesian students who also have high numeracy skills.

Theme 4: Interprenting The Result

Interpreting results is essential as it allows students to make sense of the outcomes of problem-solving processes. This process helps students understand the correctness of their solutions, identify errors, and reflect on their problem-solving strategies (Hattie & Timperley, 2007). Interprenting the result can be the last step in solving problem. This step present in all content, but in this studies we merged it in uncertainty and data content.

Uncertainty is a phenomenon that lies at the heart of any mathematical analysis of situations. Statistical theory and probability are used to solve this phenomenon. The uncertainty and data category includes recognition of the place of variations in a process, the meaning of the quantification of these variations, knowledge of uncertainties and errors in measurement, and knowledge of chance. Presentation and interpretation of data are key concepts in this category (OECD, 2009).

Amelia et al. (2020) gave a 2012 PISA question related to uncertainty and data content aspects and found that only 5 out of 23 students were able to solve the problem. In solving this problem, at the formula stage, students are able to formulate problems and read tables, but they have not been able to determine the right variable and have a little difficulty understanding the problem. Furthermore, in the employing stage, students can determine useful information and choose one strategy from several strategies that can be used to solve problems, but they are not careful and are wrong in calculating the multiplication of decimal numbers. Then, at the interpret stage, students try to interpret the problem by drawing conclusions, but the conclusion statements that are drawn are not in accordance with the employ process. This may be influenced by the characteristics of the questions, which are complicated and require more accuracy to understand. So, students are hesitant in draw conclusions. Using the same indicators, students' numeracy skills in secondary schools in the study Ridzkiyah & Effendi (2021) still not enough, this is seen in only 3 out of 12 students who are able to fulfill the third stage of the numeracy process, including drawing conclusions from problem-solving.

The research conducting by Sahidin & Sari (2022) choose 3 subjects based on the level of mathematical ability. Low ability subjects are unable to write down facts completely and not formulate problems correctly, unable to choose the right strategy to solve problems, perform calculations both in writing and orally, and unable to draw conclusions. Subjects with high abilities and subjects with moderate abilities can carry out mathematical processes: formulating by writing down all the facts, using correctly, and interpreting by writing orally through the relationship of existing facts. Farida et al. (2021) and Widodo (2022) said that the students in this cataegory was able to interpret results of mathematics into real-world contexts.

Meta-Theme: The importance of numeracy skills in Solving PISA Problems.

Numeracy skills are crucial in solving PISA problems, as they enable students to formulate mathematical situations, choose the right solution strategy, and analyze information from various sources (Iswara, et al., 2022). These skills encompass a range of competencies, including the ability to understand and work with mathematical concepts, interpret data, and apply mathematical reasoning to real-world scenarios. In the context of PISA, numeracy skills are important as they enable students to tackle complex problems across different domains such as mathematics, science, and reading (OECD, 2013).

Effective problem-solving in PISA requires strong cognitive foundations supported by numeracy skills. These skills involve mathematical fluency, logical reasoning, and the ability to interpret and analyze quantitative information (Wu et al., 2017). Students proficient in numeracy are better equipped to comprehend problem statements, devise strategies, and verify the accuracy of their solutions.

However, many students struggle with higher-level reasoning and complex problem situations, indicating a need for improvement in these areas (Rahmawati, 2021). There is a strong correlation between numeracy skills and academic achievement. Students with higher numeracy proficiency tend to perform better in PISA assessments, demonstrating superior problem-solving abilities and critical thinking (OECD, 2016; Xiao, et al., 2019). These skills not only contribute to academic success but also enhance students' readiness for higher education and future careers requiring quantitative literacy. Despite these challenges, providing reasoning questions similar to PISA problems can help students enhance their numeracy skills.

▪ CONCLUSION

Students' numeracy skills are an important ability for students to understand mathematical concepts and apply them to solve their daily problems. Solving PISA model questions that carry the main indicator, namely numeracy ability, is something that Indonesian students are expected to get used to. In the 18 studies discussed, it was found that students' abilities in this matter were lacking, especially in the low group. This applies to the 4 contents proposed by PISA, namely space and shape, change and relationships, quantity, uncertainty, and data. The numeracy skills of Indonesian students in general are still at level 3 when solving PISA model questions. Only a few students have abilities above that level. It is hoped that this research can be a joint reflection for educators in developing students' numeracy skills in mathematics learning by frequently providing PISA model problems so that students are accustomed to solving high-level questions, which results in increasing students' numeracy skills as well as their rankings on international PISA assessments.

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